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Printed in Holland

Hydrobiological Studies on the Tugela River System

Part II.

Organic Pollution in the Bushmans River

BY

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Contents

1. Introduction

This study of organic pollution in the Bushmans river and a tributary, the Little Bushmans river in the vicinity of Estcourt, was undertaken as part of a study of the rivers of the Tugela River Basin being conducted by the South African Council for Scientific and Industrial Research, on behalf of the Town and Regional Planning Commission of the Natal Provincial Administration.

The Bushmans river was selected for study, from a number discovered to be polluted in the basin, because it was more extensively polluted than most of the others, and because it was polluted from a number of different sources in a relatively short stretch of river. The main contributions to the pollution came from a boardmill, a milk-processing factory, and an irrigation farm used to dispose of sewage.

In the tributary named the Little Bushmans river, pollution resulted from contributions to the river of material in the two factory effluents. In addition the state of the river was aggravated by the decomposition of beds of fibrous and organic material deposited in the river below the entries of the effluents. The pollution in the main river arose partly from the inflow of the Little Bushmans river, and partly (in fact mainly) from effluents draining from the sewage-disposal farm. It was never heavy, as the additions never constituted more than a small proportion of the flow of the main river.

2. Description of the area

A map of the area showing the positions of the sampling stations on the rivers appears in Figure 1.

(a) The Little Bushmans river. – The catchment of Little Bushmans river lies wholly on beds of the Beaufort series, a formation yielding a well-buffered slightly alkaline water. The river rises on the north eastern slopes of Thabamhlope at an altitude of about 5,000 feet, and runs about 20 miles by gentle gradient to Estcourt at 3,800 feet. The gradient over the last few miles above Estcourt is somewhat steep, and the river finally runs into Estcourt from the West and joins the Bushmans river directly below the town.

Above Estcourt the river is comparatively uniform, and can be compared with the transition between the end of the Foothill Torrent zone, and the beginning of the Foothill Sand Bed Zone at the Cavern's Causeway on the Tugela river (Oliff, 1960). Directly above Estcourt, rapids and long pools alternate in the river.

The catchment, which is 76 square miles in extent, lies in the summer rainfall zone between the 30″ and 50″ Isohets, and is thus a

FIGURE 1.

MAP OF THE CATCHMENT OF THE BUSHMANS RIVER
IN THE VICINITY OF ESTCOURT.

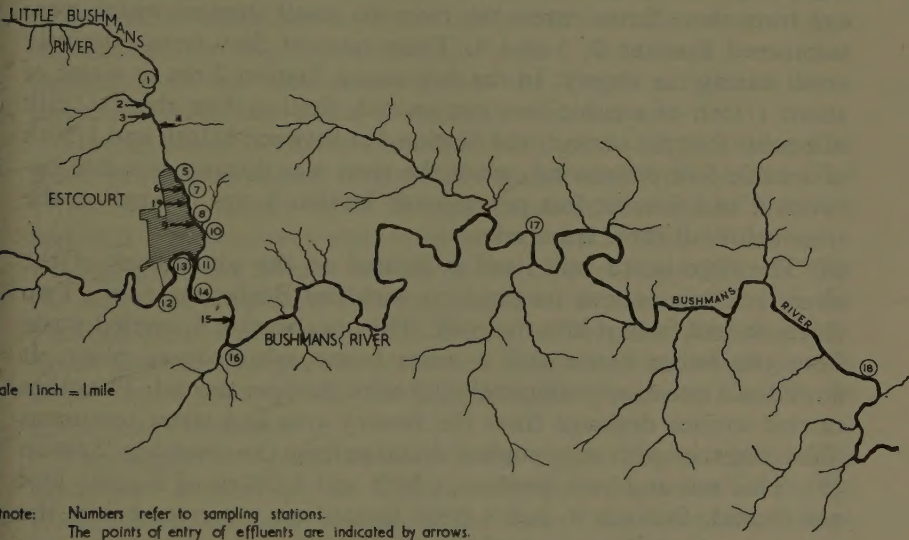


Figure 1. Map of Area showing stations and sources of pollution.

little drier than the catchment of the upper Tugela. The vegetation is uniform Southern Tall Grassveld, except for a short stretch of Valley Bushveld which occurs at Estcourt.

Unfortunately, no accurate records of flow are available. It is necessary thus to rely on a few isolated measurements made by means of a temporary V-notch weir in winter, and upon measurements based upon estimates of cross-sectional areas and current speeds in summer. In the winter flows varied between 2 and 6.5 cusecs, with an average of 4 cubic feet per sec. The flow at normal summer level was measured as 50 cusecs, though the summer flow varied considerably, depending on the rainfall, and rates were measured of 67 cusecs, in February, and 200 cusecs, in October, during a flood.

Sources of contamination: The upper part of the Catchment lies largely in the Drakensberg Native Location, Number 1. Below this most of the basin is agricultural land, and any material entering the river above the region of pollution at Estcourt comes only from farms. Station 1 was located on the river 7 miles above its junction with the Bushmans river, upstream of all known sources of urban and industrial pollution.

The sources of pollution in the Estcourt area were as follows:
(i) Two farms used by a fibre-board mill for the irrigation of waste waters lie on the south and north banks of the river, about 6.5 and 4.5 miles respectively above its junction with the Bushmans river. Drainage from these farms enters the river via small streams which were numbered Stations 2, 3 and 4. Their rates of flow were relatively small during the survey. In the dry season Station 2 ran at a rate of about 1/36th of a cubic foot per second, Station 3 at about 1/25th of a cubic foot per second, and Station 4 at between 1/16th and 1/20th of a cubic foot per second, when the river was flowing at a rate between 2 and 5 cubic feet per second. Station 5 was located on the river below all these tributaries.
(ii) The fibre-board mill itself is located on the south bank of the river, 1.5 miles above its junction with the Bushmans river. Two channels lead from it into the river. The one, Station 6, carried waste from the boiler house and a water-borne ash-recovery plant. It flowed at a rate of approximately 0.2 cubic foot per second. The other carried surface drainage from the factory area and water treatment plant, together with some surface drainage from the township (Station 19). This ran at a rate between 1/50th and 1/200th of a cubic foot per second. Stations 7 and 8 were located on the river below the points at which these channels entered.

Pipe-lines running across the river from the factory to the disposal farms were another source of occasional intermittent pollution, when they burst. The breaks were usually noticed and repaired after a few hours.
(iii) Waste from a milk-processing factory in Estcourt enters the river on the south bank about 0.8 of a mile above its junction with the Bushmans river (Station 9). This was composed of condensate, floor washings, and coffee-bean residues on occasions, and was often quite warm (15° higher than the river water on occasions). It flowed at an average rate of about 0.65 of a cubic foot per sec. Station 10 was established below the entry of the effluent.
(iv) Finally the main sewer of the township, which lies on the bank of the river about ¼ mile above the junction, was a source of pollution in time of rain, or flooding, or when overloaded, as the sewage then flooded out of man-holes at low points on the bank, and poured directly into the river. Surface drainage from the township enters the river at many points. Station 11 was established on the river immediately above its junction with the Bushmans river.

(b) The Bushmans River. – The catchment of the Bushmans river above Estcourt, like that of the Upper Tugela, arises on the basaltic lavas and Stormberg sandstones of the Drakenberg, and it lies almost

wholly on beds of the Beaufort series. It rises at Giant's Castle at an altitude of about 8,000 feet, and flows, at first precipitately, and later more gently, in a narrow and comparatively shallow valley first to Dalton Bridge, 9 miles above Estcourt, then down to Estcourt at 3,800 feet, 41 miles below. Below this point, the valley deepens and widens, and the river flows through broken, rather arid areas, over formations of the Ecca series, to join the Tugela at Nkasini at an altitude of 2,200 feet, about 85 miles from its source.

The catchment lies in the summer rainfall area: 16.5% of the catchment, in the headwaters, receives an average rainfall of over 50 inches a year: 38.8%, largely above Estcourt, receives between 30″ and 50″; and 44.6% in the lower river receives between 25″ and 30″ a year.

In general, the river is similar to the Upper Tugela, except that the zones are longer. At Estcourt, the river is comparable with the Foothill Sand Bed Zone of the Tugela at Bergville (OLIFF, 1960). Below Estcourt the river enters a zone of rejuvenation which persists in the lower valley to its junction with the Tugela at Nkasini, 38 miles below Estcourt.

The vegetation resembles that of the Upper Tugela Valley. The catchment commences in Themeda-Festuca Alpine veld on the Drakensberg, and soon changes at the base of the mountain, first to Highland Sourveld which extends to Dalton Bridge, and then to Southern Tall Grassveld which extends as far as Estcourt. Below this the vegetation is uniform Dry Thorn or Valley Bushveld.

337 square miles of the catchment lie above Estcourt, and about 300 square miles lie between Estcourt and Weenen. The average rates of flow gauged at Estcourt in summer and in winter 1954—55, were 533 cusecs, and 63 cusecs respectively. The rates at Nkasini just above the junction with the Tugela, on the other hand, were estimated as 1186 cusecs. in summer and 140 cusecs in winter. (Table 1, Fig. 2). (cf. Tugela River, OLIFF.)

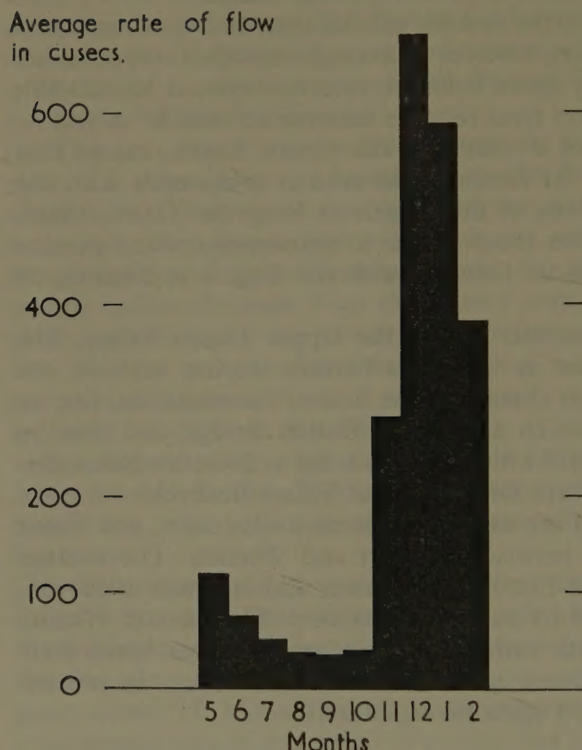
Sources of contamination: The river rises in the Giant's Castle Nature Reserve and flows for a large part of its course along the boundary of the Drakensberg Native Location No. 1. It then passes through farming country to Estcourt. No changes associated with pollution were ever observed in the river directly above the township, and the uppermost point, Station No. 12, was located here.

There were the following sources of pollution:

(v) Directly below Estcourt there was some sporadic pollution from the township: Surface drainage from the town entered the river which is impounded by a dam, (Station 13); sewage leaked from the main sewer in the dam wall at times, and surface and storm-water drains entered below the dam.

FIGURE 2.

AVERAGE RATES OF FLOW IN THE BUSHMANS RIVER BETWEEN MAY 1956 AND FEBRUARY 1957.



NOTE: Flows above 200 cusecs are estimates of minimum flows, and not of total flows, as the weir was submerged at this level.

Figure 2. Average rates of flow in the Bushmans river in 1956—1957.

(vi) The Little Bushmans river joins the Bushmans river from the North, just below the township. It constituted the first major pollutant, and Station 14 was sited below the junction. A turbine pumping plant, operated by water from the Bushmans river, lies a half-mile below the junction. The pump delivers waste to the sewage farm from

the main sewer on the bank of the river, and was a source of some pollution, for sewage leaked from glands in the pump, and overflow of unknown volume was returned directly to the river.

(vii) At the sewage farm the sewage was run through a system of furrows, and was then irrigated over lucerne and grasslands on the river bank. The slope of the land is considerable, and a fair amount of sewage found its way both overland, and by sub-surface drainage, into channels on the river bank, and so into the river. Station 15 was on one such channel. The quantities discharged were variable, and the flow in this channel was measured as nil, 0.5 and 2.5 cubic feet per second on different occasions. Station 16 was located on the river below the farm, about 5 miles below the junction of the Little Bushmans river.

No other source of pollution was found in the course of the river, though water is taken out for irrigation and large portions are returned overland. Station 17 was located 10 miles below the Little Bushmans junction, and Station 18 was located just above Weenen, some 23 miles below the junction, where the study was concluded. Below Weenen some pollution occurs where irrigation water from the settlement is returned to the river laden with soil and organic matter, and probably also with fertilisers. Fifteen miles below Weenen, the Bushmans river joins the Tugela.

3. Methods

Twelve sampling points were established on the Little Bushmans river, and seven on the Bushmans river. These were visited at intervals of between one and three months for chemical and biological analysis.

The positions of the stations were selected to enable comparisons to be made between communities in polluted and unpolluted areas. Station 1 on the Little Bushmans, and Station 12 on the Bushmans were free from obvious pollution, and Station 18 on the Bushmans near Weenen, 23 miles below Estcourt, was probably unpolluted at most times. All other stations suffered some degree of pollution. Their positions are shown in Figures 1 and 2. Figure 10 (in appendix) also indicates the degree of pollution of the river.

Three major biological habitats were sampled: Stones in rapids, marginal vegetation, and the bottom sediments. The rapids selected had beds of loose stones, which were very roughly from 3 to 12 inches in greatest linear dimension. Current speeds in the rapids were usually between 1.5 and 3 feet (48 and 91 cm) per second. The marginal vegetation sampled in slow reaches, consisted usually of a trailing fringe of the grass, *Cynodon dactylon* and the weed, *Polygonum*

setulosum. Some patches of *Phragmites communis* were sampled at Weenen, where grass was not so common. Current speeds near the margin were usually under 0.1 feet (3 cm) per second. The bottom sediments were generally composed of fine sand, except at contaminated stations, where sludge and organic deposits also were present.

The analytical methods employed were similar to those used in the survey of the Tugela river (OLIFF, 1960). Additional analyses were made of the amount of dissolved oxygen, and of the 5-day Biochemical oxygen demand. For the biological work nets of 60 meshes to the inch were used throughout, (24 meshes per cm. Aperture approximately 0.3 mm) in order to sample the numbers of small worms and Chironomidae accurately. This was finer mesh than was used in the work on the Tugela.

One innovation was that a simple glass cylinder, 62 mm in diameter, was used to sample a core of the bottom sediments, (the Birge-Ekman grab leaked and proved unsuitable in fibrous, loosely-packed detritus in shallow water). The cylinder, closed with fine mesh netting at its upper end, was forced firmly into the sediment, and the bottom closed by sliding a metal plate under the rim. The closed cylinder was then inverted under water to prevent loss through leakage, and removed to a bucket. This procedure was repeated until sufficient material was obtained. The sample was then freed from sand and stones by stirring and filtering the suspension through fine mesh netting.

The units employed were: a Surber sampler one square foot in area (930 sq. cm) in stones in rapids; a sweep ten feet in length (3.0 m), with a 10 inch (25 cm) diameter hand net in marginal vegetation; and a core nine square inches in area, (58 sq. cm), in bottom sediments.

Usually between two and five units were collected at each sampling, but the numbers have been reduced to a convenient level, for comparison in the tables. This level differs from that used in the Tugela, and the collections are not comparable numerically with those made in the earlier survey of the Tugela, with a different mesh net.

4. FINDINGS OF THE STUDY

Definition: There is some difficulty in defining the meaning of the word pollution. The general concensus of opinion appears to favour the sense of 'the destruction of purity' or 'the infection of a normal water', resulting in a 'disturbance or change in the normal community of a water', and the word is used in this sense throughout this paper.

The study of pollution in the Bushmans river, though selfcontained, was designed to be viewed against the broad background of

the survey of the virtually unpolluted Tugela river, (OLIFF, 1960)- In this context the communities of polluted sections of the Bush. mans river stand out in striking contrast to those occurring throughout the main Tugela river, and it is clear that the plant and animal associations are sensitive and reliable indicators of the state of the river.

(a) General Effects of Specific Pollutants:

It is useful at this stage to distinguish briefly the effects of each specific type of pollution encountered in the rivers before considering degrees of pollution in greater detail. They are listed in order of increasing severity.

(i) Pollution of the Little Bushmans river below the board-mill effluent-disposal farms was light, and was due to the addition of organic and inorganic material in solution. This resulted in increased levels of 5-day BOD., and 4-hour OA (permanganate), and increased concentrations of dissolved solids, (chlorides, bicarbonates, and magnesium) in the river water. The quantity of algae, and the density of animals was also greater than that found at unpolluted stations, though there was no marked change in the species composition of the communities. The effect of this pollution might be termed nutritive.

(ii) Pollution of the Bushmans river was light below the inflow of the Little Bushmans tributary, which carried organic and inorganic material in solution, and the results were slight increases in level of 5-day BOD, and 4-hour OA, and the concentration of dissolved solids in the river. The density of the usual flora and fauna also increased without any great change in species composition.

(iii) Pollution of the Bushmans river below the sewage disposal farm was heavier; it resulted in an increase in the level of 4-hour OA, but not of 5-day BOD, and also in an increase in the concentration of dissolved solids, (nitrates, sulphates, and chlorides) in the river. The bulk of algae: *Oscillatoria* spp., *Spirogyra* spp., and *Cladophora* sp. also increased, as did the numbers of animals. There were in addition, changes in the composition of the fauna: The number of species of Ephemeroptera and Trichoptera was restricted; the numbers of Oligochaeta on the other hand, became considerable; and the planktonic Cladocera and Copepoda, *Simocephalus vetuloides* and *Paracyclops poppei* increased in numbers in the mat of algae, particularly in the marginal vegetation of slow-flowing stretches.

(iv) Pollution of the Little Bushmans river below the fibre-board mill effluents was heavy, and resulted in increased levels of 5-day BOD, and 4-hour OA, and in increased concentrations of dissolved solids, free and saline ammonia, sulphates, chlorides, and calcium in the river. Also sediments and fibre were deposited on the bed. The

flora was restricted mainly to masses of "sewage fungus" [1]) organisms, with some *Oscillatoria* spp., and *Spirogyra* spp. The fauna was restricted to large numbers of Turbellaria, Nematoda, Naididae, and Tubificidae. A peculiar feature at this station was that the uppermost parts of the bed and banks for some distance (Station 7) were coated with 'tall-oil' discharged in the effluent. This oil disappeared above Station 8, where the amount of algae and the number of worms was considerably higher.

(v) Pollution of the Little Bushmans river by the large amount of organic matter discharged by the milk-processing factory was relatively heavy, and resulted both in increased levels of 5-day BOD, and 4-hour OA, and in increased concentrations of nitrites, and nitrates in the river water. In addition sediments were deposited on the bed. The flora was composed mainly of masses of sewage fungus organisms, with some *Spirogyra* spp. at the surface and margins. The fauna was composed solely of large numbers of Turbellaria, Nematoda, Naididae and Tubificidae.

Polluted conditions persisted in the Little Bushmans river to its junction with the main river, with some minor changes where it runs through long slow pools constituting a more lentic type of environment, in which large numbers of Cladocera and Copepoda were found.

Briefly, pollution of the tributary, the Little Bushmans river, arose from additions both of organic and of inorganic material in solution and suspension. The most deleterious material however was organic matter in suspension which settled out and blanketed parts of the bed, for these beds in time became major sources of soluble organic and inorganic material. The flora of the stream immediately below the beds was restricted mainly to sewage fungus organisms, and the fauna was restricted almost solely to worms.

Pollution in the main Bushmans river on the other hand, arose from enrichment with mineral and organic material in solution, which came both from the Little Bushmans tributary, and from the sewage-farm effluents. The greater part of the material was mineral, and the enrichment of the river water resulted in heavy growths of algae; *Spirogyra* spp., *Cladophora* sp., *Stigeoclonium* spp., *Oscillatoria* spp., accompanied by a dense animal population composed of species normally found in unpolluted rivers, augmented by many Oligo-chaeta.

The communities associated with the different types and grades of organic pollution can be arranged in a series grading from those of light, to those of heavy pollution. It must be recognised that this

[1]) (The complex referred to generally as sewage fungus was composed variously of cf. *Sphaerotilus* sp., *Oscillatoria* spp., and *Phormidium* spp.)

series did not occur naturally in order, because, as described, pollution of different degrees occurred simultaneously at a number of different points on the rivers. Nevertheless, as the pollutants ultimately were all largely of organic origin and all flowed ultimately in the same system, the series is a natural one, and differences between communities have been recognised as indicating differences in the degree of pollution.

(b) The results of chemical analyses of the river water.

Treatment of results: In order to generalise the finding of the study and bring out differences most clearly, the five analyses done for each station in May, June, July, September and October respectively, during the period of low flow, have been combined, and an average has been calculated for each station. This procedure effects some smoothing of the data, and any consistent long term differences between the stations are brought out. In addition, in describing the types of flora and fauna, only the dominant forms are mentioned, and broad categories of abundance are used for the sake of brevity and simplicity, though the actual numbers have been given in Tables 7, and 9 (in appendix).

The average chemical conditions observed at the sampling stations during the dry season have been tabulated in Table 2, and the main features have been plotted diagrammatically in Figure 3. In reality the conditions were not constant but varied in different months about the average as indicated in Figure 4. The extreme values encountered are given in table 3.

(i) Contaminating Material:

The changes in concentration of dissolved solids, in amounts of oxygen absorbed from permanganate in 4 hours, and of 5-day BOD, in sections of the river are given in Table 4.[1]) The increments, of approximately 60 ppm. of dissolved solids, of about 3 ppm. oxygen absorbed from permanganate in 4 hours, and of 4—7 ppm. of 5-day BOD in the Little Bushmans river; and the changes of 1.2 ppm. of 4-hour OA, and of 0.7 ppm. of 5-day BOD, in the Bushmans river, are not large when compared with the considerable changes observed in the flora and fauna of the sections.

As the averages were based on the analyses of spot samples taken at monthly intervals, it was considered advisable to examine the more important effluents in rather greater detail, to ascertain if their composition was at all uniform.

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[1]) Some of the changes, particularly those of oxygen demand, are small, and of doubtfull significance, but have been included for completeness.

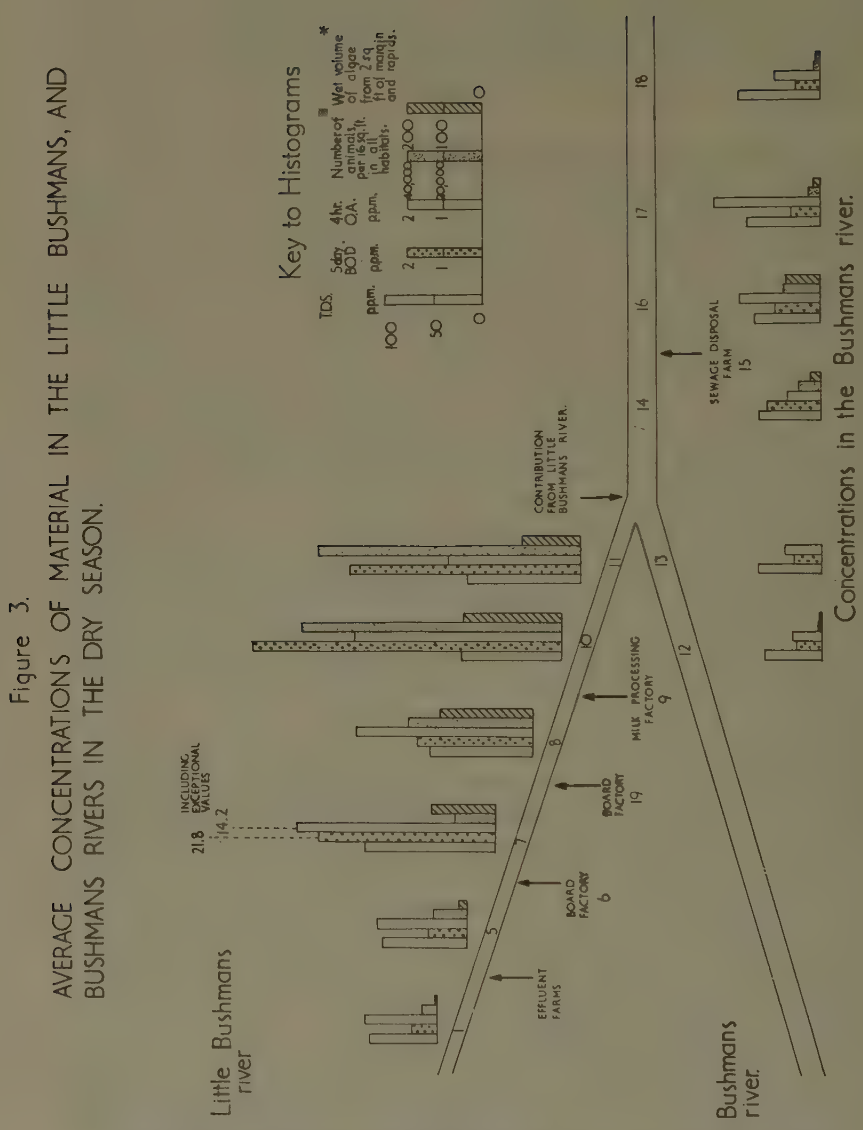

Figure 3. The average concentrations of material in the dry seasons.

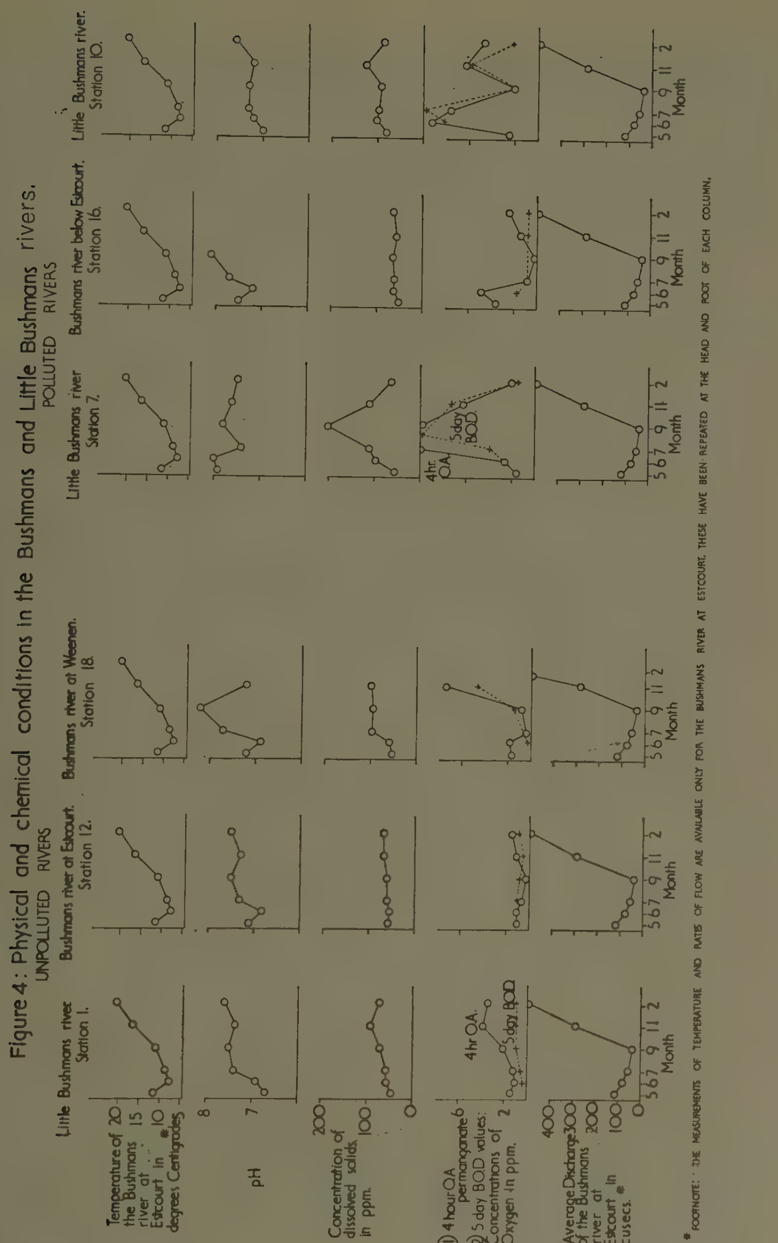

Figure 4. Physical and Chemical conditions at stations on the Bushmans and Little Bushmans rivers.

The board-mill effluent was examined at approximately hourly intervals over a $9\frac{1}{2}$ hour period, and it was found that the average amount of oxygen absorbed from permanganate in 4 hours was 28.6 ppm., which was much higher than the average of the spot samples (5.1 ppm.). The 5-day BOD value was 33.6 ppm. which was likewise much higher than the average 2.7 ppm. of the spot samples. The composition of the effluent was widely variable (5-day BOD, 3—125 ppm.). Thus it seems possible that the effluent may have had a demand for oxygen much higher, (5—10-times) than has been estimated from monthly samples alone.

The milk-processing factory effluent was also studied over a $6\frac{1}{2}$ hour period, and average hourly analysis of 2.8 ppm. of oxygen absorbed from permanganate in 4 hours (cf. 7.3 ppm. for spot samples), and of 7.8 ppm. 5-day BOD (cf. 13.4 ppm. for spot samples) were obtained. The composition of this effluent was more uniform, and the average based upon monthly samples was probably of the correct order.

It appears, from a consideration of loads in the section below the entries of the two main effluents, that not all material in the river can be accounted for in the effluents. In fact the level of dissolved solids in the river below the board factory was 8 times higher, and the biochemical oxygen demand was $2\frac{1}{2}$ times greater than could be accounted for (including the high values for the board-mill effluent). Similarly the biochemical oxygen demand below the effluent from the milk-processing factory was 3 times greater than could be accounted for. Thus, although much of the polluting load in the Little Bushmans river can be traced to the two main effluents entering the river, nevertheless not all the load can be explained in terms of them directly, and a considerable portion came from another source, which was deduced to be the deep beds of sludge in the river below their entries. These beds arose by deposition of materials suspended in the effluents, and were of such importance that they will be considered in some detail.

The first sludge bed accumulated below the entry of the board-mill effluent, Station 6. The river flowed slowly at this point, through pools about 2 feet deep and, in the winter months when the flow was not great, ash and fibre in the effluent settled and formed a large bed extending some 50 feet downstream. A second bed accumulated below the entry of the effluent at Station 19 in the same way. Some few comparisons on particular occasions indicated that the daily load of suspended solids in the river decreased by about 100 lbs. (45 kg) between Stations 7 and 8. This material must have settled on the bed, and deposition at this rate would result in the accumulation of about four tons of sediment in 3 months. Approximate measurements of the extent of the sludge beds in the river indicated

that this was actually the order of magnitude of the sediments. A third bank collected below the effluent at Station 9 from the milk-processing factory. This effluent carried a load of milk and coffee-bean residues on occasions, some of which settled and formed banks extending 50 to 100 yards downstream.

The main points about the composition of the beds are detailed in Table 5. (It should be noted that these are analyses of single samples). The sediments were rich both in organic and inorganic material, and formed a continuing additional source of polluting material in the bed of the river. One of the effects of the banks was dramatically illustrated at Station 7 during September, when anaerobic decomposition of the material seems to have accelerated as the temperature rose in early Spring. This resulted in the evolution of gas, which lifted, and effectively stirred the material. As a result, a very high permanganate oxygen absorption value of 50 ppm. and a 5-day BOD of more than 73 ppm. were obtained in the turbid river, while the dissolved oxygen was only 32 % of saturation at noon. Similar effects were observed at the other sludge banks. These banks therefore appear to be responsible for the supply of organic and inorganic material which could not directly be traced to the effluents entering the river.

(ii) Dissolved oxygen:

Some determination of the percentage saturation of oxygen in the river were made at various times, and some of these indicated that depletion of oxygen occurred at contaminated stations. This depletion, which occurred only when the rate of flow of the river was low was probably the result of the demands for oxygen exercised both by organic material in the river water, and by the masses of animals, and algae (at night), and serves as an indication of the degree of pollution.

The level was exceptionally low (32 %) during the day at Station 7 in September, when the sludge banks were disturbed, and was also low at dawn in October when the rate of flow of the river was low: values of 63 % at Station 7, 27 % at Station 10, and 68 % at Station 11, were measured at dawn on this occasion.

It is noteworthy that the milk-processing factory effluent (No. 9) was relatively warm, and the subsequent cooling of the water when it entered the river, gave rise to an average immediate demand for 1.54 ppm. of oxygen in the effluent, over its normal BOD.

No serious depletion of the oxygen content was expected in the Bushmans river, for the oxygen reserve, even during low flow, was 3,500 lbs. (1588 kg per day) which far exceeded the demand for about 100 lbs. (45 kg) of oxygen per day.

Some evidence of supersaturation was obtained during September at Stations 8, 11, 15 and 16, when the river was low. All these stations supported obvious, heavy growths of algae, and although the magnitude of the supersaturation was not large, (105%—110%) it was sufficient to indicate the effect of the algal growths in the river.

(iii) Seasonal variations in conditions:

The seasonal changes in the river affecting the environment of the fauna and flora were firstly, differences of temperature and secondly, considerable changes in the rate of flow. The high flows in the summer, wet season, caused considerable abrasion and scouring in the river, and the low flows in the winter; dry season, resulted in increased concentrations of dissolved materials in the river. (cf. also Part I of the series of Studies, OLIFF, 1960).

Figure 4 and Table 6 give details of these changes. At contaminated stations there were in addition, during the dry season, the effects of a steadily increasing concentration of contaminating material in the dwindling flow of the river, (though the loads of contaminating material in the effluents themselves remained roughly constant during the period of study).

(c) **The Flora and Fauna.**

(i) Presentation of data:

Average numbers in the fauna during the dry season at all stations are listed in Tables 9—11 (in the appendix).

Average numbers of individuals in major groups at each station during the dry season are plotted as histograms in Figure 5, and the actual numbers collected each month are shown in Figure 6. The approximate wet volume of algae in each habitat is recorded in Table 12 (in the appendix).

(ii) The major features of communities in all habitats: (Tables 9, 10, & 11 in appendix) —

1. The density of individuals both of algae and animals was relatively low at normal stations, and the number of different species was relatively high.
2. In contrast, the density of individuals both of algae and animals was high at polluted stations, but comparatively fewer species were represented. In addition, the heavier the pollution, the greater was the density of the fauna and flora. E.g. in stones in current in the Little Bushmans river, at Station 1, which was unpolluted, there were 6,241 individuals belonging to 45 different species, whereas at the heavily polluted Station 10, there were 27,738 individuals of 19 different species.
3. At unpolluted stations each type of habitat had a distinctive fauna,

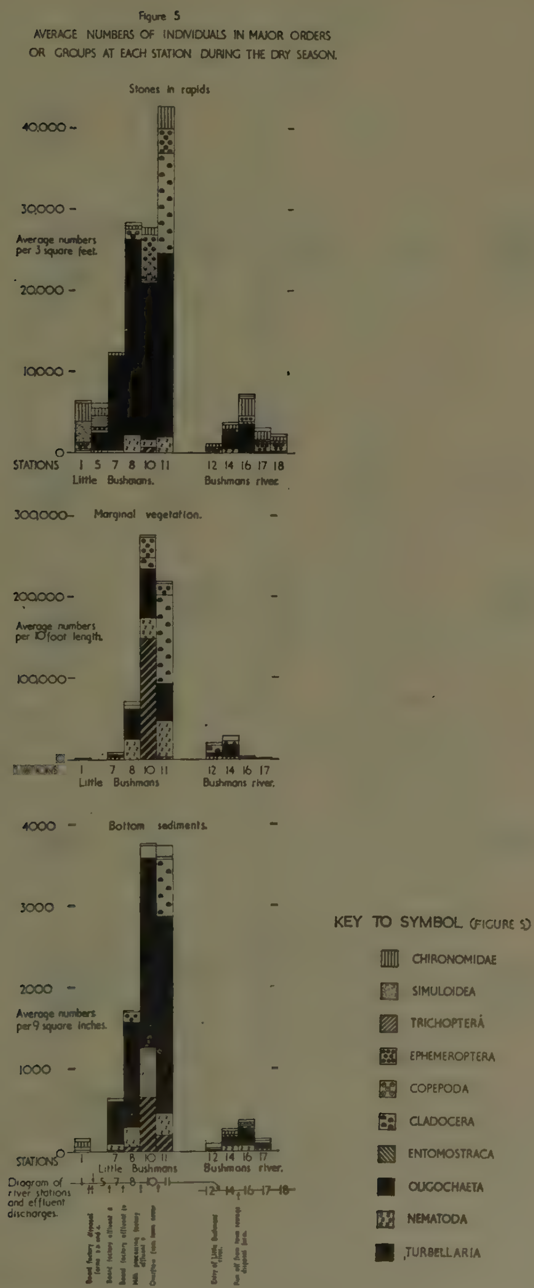

Figure 5. Average numbers of individuals in the major groups at each station during the dry season.

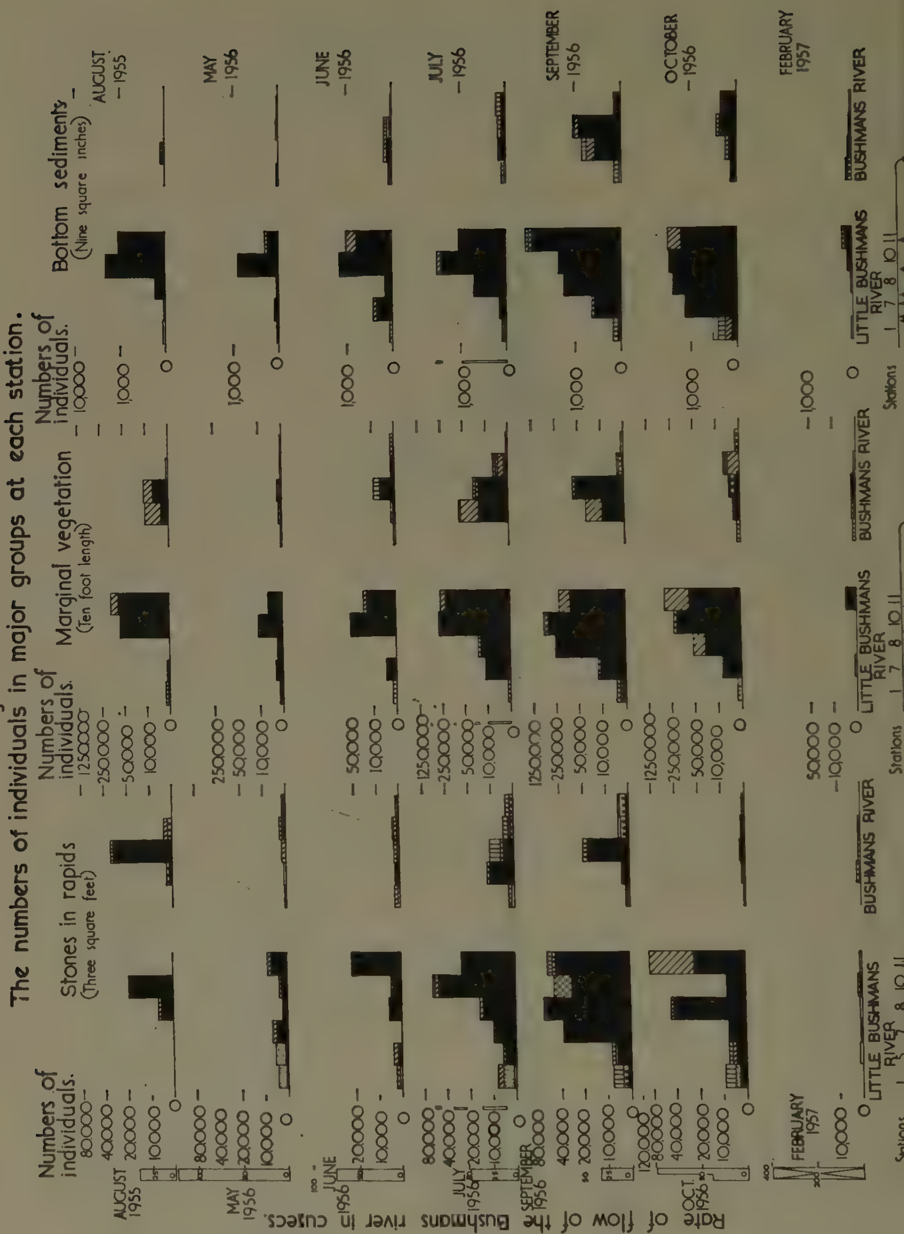

Figure 6. The numbers of individuals in the major groups at each station in each collection during the survey.

Explanation of figure 6.

1. Each separate block of the monthly histograms indicates the number of individuals in the population at the particular station numbered below.

2. The numbers of individuals have been plotted on a progressive scale with numbers doubling at each main division. Between main scale divisions however, linear scales have been used.

   i.e., 1 Major division between 0—20,000 = 10,000 individuals.
   $^1/_{10}$ = 1000 individuals.

   i.e., 1 Major division between 20—40,000 = 20,000 individuals.
   $^1/_{10}$ = 2000 individuals.

   i.e., 1 Major division between 40—80,000 = 40,000 individuals.
   $^1/_{10}$ = 4000 individuals.

3. Blocks beside scale divisions in the July series, indicate the relative size of the steps in the progressive scale used.

4. The rates of flow of the Bushman's river at the times collections were made, have been plotted at the left of the diagrams, and indicate the relative rates of flow each month.

5. The geographical positions of the sampling stations, and the location of the entry of the effluents are indicated beneath the histograms.

6. The species inhabiting each of the three habitats, stones in rapids, marginal vegetation, and bottom sediments are plotted separately.

but at polluted stations faunal differences between habitats be-became less or disappeared, and the same types mainly Turbellaria, Nematoda, Naididae, Tubificidae and Hirudinae, were found everywhere.

4. Some species were restricted by pollution: Many found in clean streams were not found at all in polluted water (Ephemeroptera & Trichoptera), and on the other hand, species which predominated in polluted places were not found, or occurred only in small numbers in the fauna of unpolluted streams (e.g. the previously mentioned worms).
5. The main characteristics of the community associated with the type of organic pollution studied were:
   (a) The presence of a large volume of Schizomycetes c.f. *Sphaerotilus* sp.,[1]) and of algae carpeting the habitat, composed mainly of the species *Phormidium* spp., *Oscillatoria* spp., *Oedogonium* spp., *Stigeoclonium* spp., *Spirogyra* spp., and Diatoms.
   (b) The presence of large numbers of Turbellaria, *Sorocelis* sp. and *Microstomium* sp., Nematoda, including *Nygolaimus* sp. 1; Annelida, especially the Naididae; *Chaetogaster* sp. 1, and *Nais* sp. 1; Tubificidae, *Limnodrilus* sp. 1; and Hirudinea, *Glossiphonia* sp.
   (c) The presence of large numbers of Entomostraca, especially the cladocerans, *Alona cambouei* and *Alona guttata*, and the copepod, *Paracyclops poppei*.
   (d) The presence of relatively large numbers of the ancylid, *Burnupia* sp.
   (e) The absence of Plecoptera, Ephemeroptera, Trichoptera, Coleoptera and *Simulium* spp.

These general trends are well known and documented in European and American literature, and have also been recorded in the Cape (Harrison, 1958), so it is interesting, but not unexpected, to find them repeated in Natal.

(iii) Seasonal variation in communities: During the dry season there was a progressive increase in faunal density at all stations. In addition the communities at the polluted stations became progressively more distinct as the dry season advanced, until they were finally washed away by the first heavy flood of the wet season.

The numbers of individuals within certain groups, shown in Figures 5 and 6, indicate the general trend for progressively higher densities between July and October, with enormous numbers at

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[1]) The complex referred to generally as sewage fungus was composed variously of cf. *Spaerotilus* sp., *Oscillatoria* spp., and *Phormidium* spp.

Figure 7. The numbers of more important species in stones in rapids each month at typical stations.

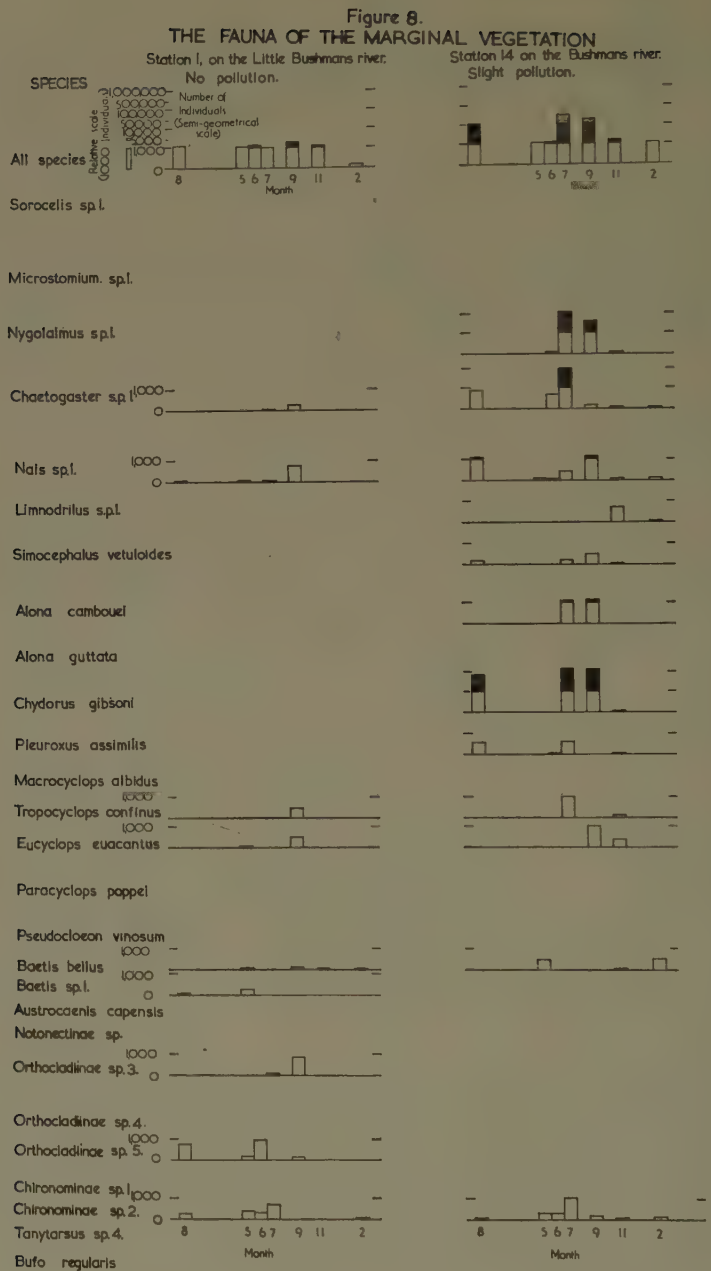
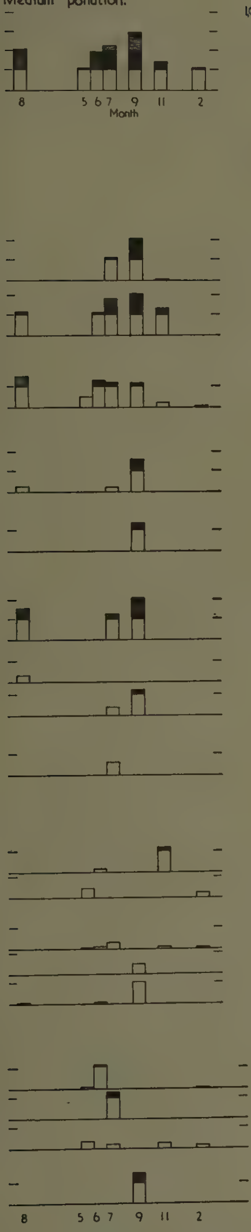
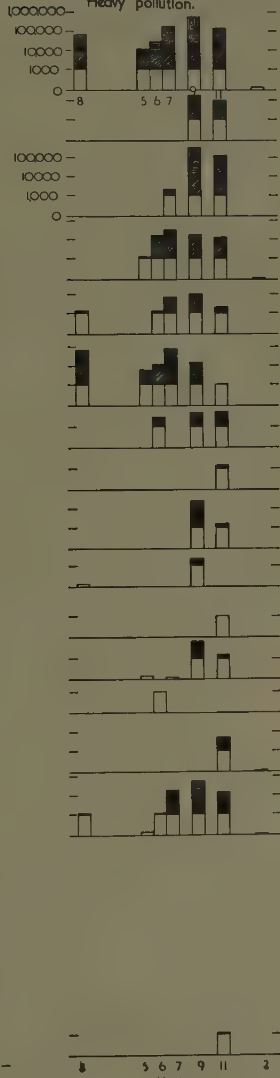


Figure 8. The numbers of more important species in marginal vegetation each month at typical stations.

Station 16 on the Bushmans river.
Medium pollution.



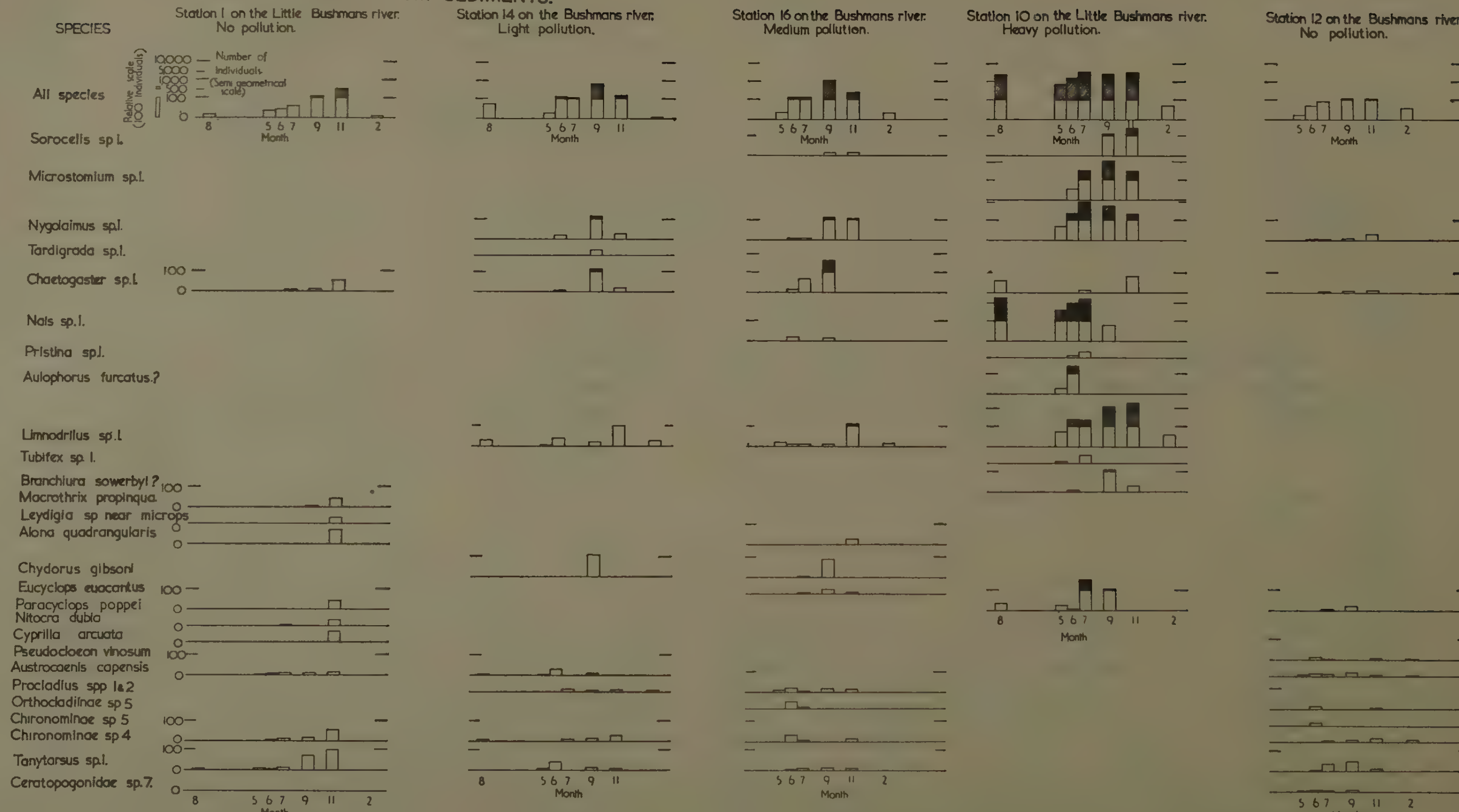
Station 10 on the Little Bushmans river.
Heavy pollution.



Station 12 on the Bushmans river.
No pollution.

Figure 9.

FAUNAE OF THE BOTTOM SEDIMENTS.



polluted stations in all three habitats independently; the rapids, the marginal vegetation, and the bottom sediments. The trend actually depends largely upon increases in numbers of the few significant species, named in Tables 7a, b and c. The actual numbers of the more important species have been plotted in Figures 7, 8 and 9, and it appears that little precision is lost in considering trends of groups, rather than of particular species in these instances, though the practice can be dangerous if changes in numbers of individual species are not also known.

This seasonal trend resulted from the progressive reduction in volume of water flowing in the rivers during the dry season, and the consequent concentration of polluting material mentioned previously. The opposite effect was seen in the wet season during high flows, when the fauna was sparse at all stations, and there was not much difference between the communities at polluted and unpolluted stations. This was probably a result, both of the extreme dilution of the contaminating materials, and of the scouring away of all deposited material.

A point of considerable interest is that conditions in the river in August, 1956 showed many resemblances to those in the same month of the previous year, though numbers were not quite the same. This suggests that the same associations recur from year to year under similar conditions, and these therefore can be used with some confidence as indicators of pollution.

5. Discussion

(a) The significance of the specialised associations of organic pollution:

An extensive literature on the nutrition of algae indicates that particular nutrients used in growth are: carbon dioxide, ammonia, nitrate, phosphate, sulphate, aminoacids, trace elements, hormones and vitamins (Fogg, 1953). Literature on the nutrition of protozoa, on the other hand, indicates that though some species are saprozoic, and have requirements like the algae, most are holozoic and depend on bacteria, plants and other animals, or their remains, for their food (Kudo, 1950). Higher animals in turn prey on the protozoa and algae, and their nutrition and growth depend on the growth of the simpler organisms.

Although the analyses undertaken for the survey were not designed to trace all the elements and nutrients which might effect the growth of organisms, nevertheless, increases in the amounts of ammonia, nitrates, phosphates and sulphates were found at the sites of pollution, and it is clear that pollution by the effluents caused the esta-

blishment of the peculiar flora and fauna with its complex of food-chain relationships.

(b) The relation of the community to the degree of contamination:

Figure 3 shows the main chemical and biological conditions at the various stations on the rivers in the form of histograms. The total numbers of animals and plants at each station have been obtained by combining the numbers of individuals collected from the rapids, the marginal vegetation, and the bottom sediments at the station, weighted by a factor in each case, such that there were equal total numbers represented in each habitat for the whole river. The combined units represent the numbers of animals per 6 square feet of combined surface area, and the wet volume of algae in ccs. per 2 square feet of area. These units are arbitrary and artificial, but form convenient parameters for comparing the combined populations in all habitats at the various stations. It is apparent (Fig. 3) that the biochemical and permanganate oxygen demands, and the relative abundance of algae and animals are more or less proportional. Further, examination of the species composition of fauna in Tables 9—11 (in the appendix) indicates that the communities at polluted stations are peculiar, and are limited more and more to certain few species of Oligochaeta and Entomostraca, as contamination becomes progressively heavier, and the habitats become altered as a result of the heavy bacterial and algal growth, and the deposition of sludge. The system of classification adopted thus is natural, and pollution is reflected both in the behaviour of the communities and in the chemistry of the river water.

(c) Self-purification:

A conspectus of the biochemical oxygen demand figures from both rivers throws some light on the course of self-purification. Most of the demand in the Bushmans river was satisfied (or perhaps inhibited) by the time the water reached Weenen. As it is most unlikely that much inhibition occured in the Bushmans river, for only one source of inhibiting material was traced, which was limited to station 7, and no others were known to occur in the area, the change in demand probably indicates that most of the oxidisable organic matter had been dealt with in this stretch of river. The figures show that the B.O.D. apparently was satisfied most rapidly near the sources of pollution. However as rates of flow are not accurately known, and as the same water was not sampled at the various points, it is difficult completely to interpret the meaning of the reduction. The percentage reductions in concentrations are listed for some sections of the rivers:

PHOTOGRAPHS

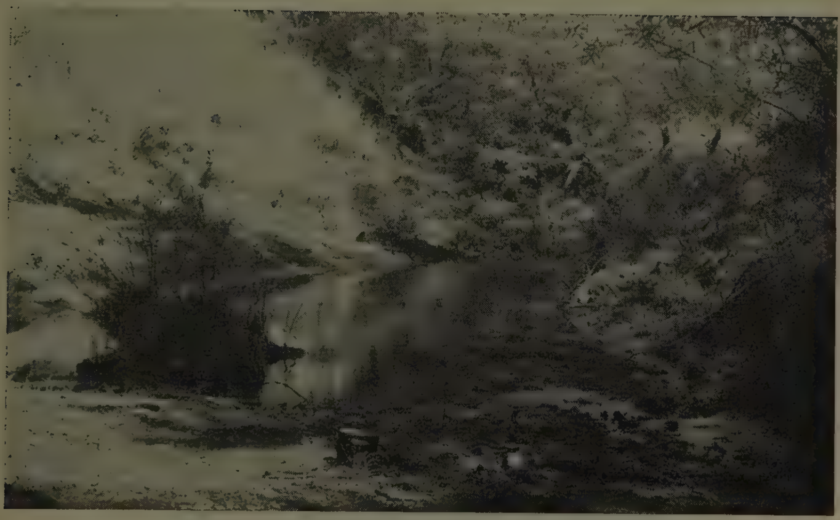


Photo 1. The Little Bushmans river at Station 1 above Estcourt.

Photo 2. The Little Bushmans river at Station 5 below the disposal farms.

Photo 3. Entry of the board factory effluent at station 7. Fibre bank in the foreground.

Photo 4. The Little Bushmans river below the entry of effluent 19. The bank of fibre is seen on the left.

Photo 5. The Little Bushmans river at Station 10.

Photo 6. The Little Bushmans river just above its junction with the Bushmans river (Station 11).

Photo 7. Station 12 on the Bushmans river above Estcourt.

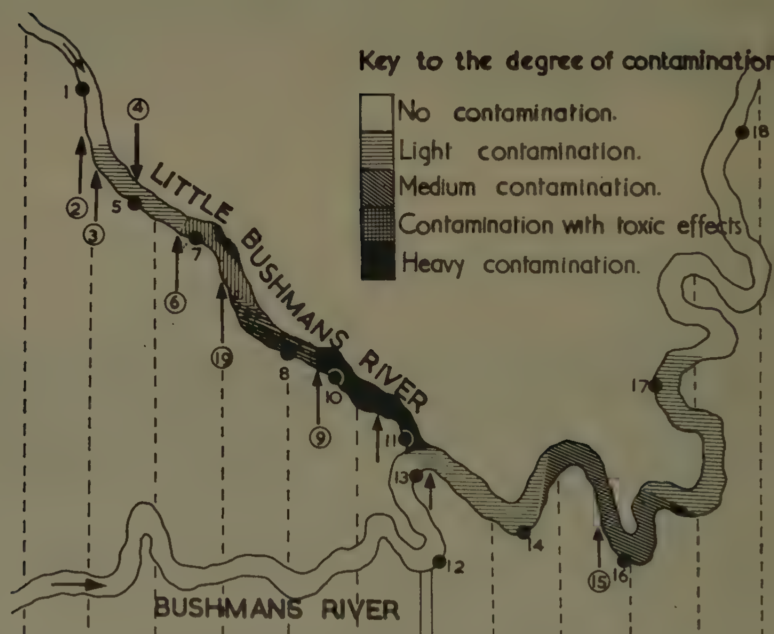
Photo 8. Station 16 on the Bushmans river below the sewage farm.

Photo 9. Station 16 on the Bushmans river below the sewage farm.

* Species not named have been catalogued under numbers, and it is hoped that a list will be published later identifying the numbered species.

FIGURE 10.

Key to Tables 9,10,11. Semidiagramatic representatio of the positions of the sampling stations on the Bushmans and Little Bushmans rivers, and of th degree of contamination of the rivers.



	LITTLE BUSHMANS RIVER						BUSHMANS RIVER				
Location	Above Estcourt.	Below Effluent disposal farms.	Below Board factory effluent.	½-mile below Board factory effluent.	Below Milk processing factory.	At Junction with Bushmans below Estcourt.	Above Estcourt	½-mile below Junction of the Little Bushmans.	Below Sewage disposal farm.	5 miles below Estcourt	10 miles below Estcourt Above Weenen.
Station number.	1	5	7	8	10	11	12	14	16	17	18

TABLE 1

MONTHLY AVERAGE RATES OF FLOW IN THE BUSHMANS RIVER AT ESTCOURT
(In Cusecs.)

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1954 - 1955	85	+ 483	+ 508	427	+ 790	+ 514	173	110	83	59	41	32
1955 - 1956	34	29	+ 302	123	+ 482	+ 569	269	119	75	51	36	35
Little Bushmans ≡ River (estimated)								.	6			2.4

≡ (The flow in the Little Bushmans River appears to be roughly .07 that in the Bushmans River.)

+ Values are minimum flows as the weir was submerged part of the time.

TABLE 2.

Average Physical and Chemical Conditions during the Season of Low Flow

(b) Conditions	Little Bushmans River												Bushmans River						
STATIONS	1.	2.	3.	4.	5.	6.	7.	19.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
1. pH	7.1	7.6	7.9	7.7	7.5	8.8	7.8	7.4	7.8	7.1	7.2	7.6	7.2	7.3	7.3	7.6	7.4	7.3	7.6
2. Conductivity in mmhos.	86	590	743	630	112	283	135	410	123	76	122	145	66	68	70	1765	80	84	100
3. Total dissolved solids in ppm.	71	406	454	426	88	147	135	372	108	74	105	118	60	66	65	1447	69	76	83
4. 5 day BOD at 20°C, as ppm Oxygen.	0.7	0.9	0.6	0.5	1.1	2.7	4.7 (21.8)	3.6	3.1	13.4	8.2	6.2	0.7	0.8	1.4	6.5	1.2	0.8	0.7 (1.7)
5. ppm. Oxygen absorbed from Potassium Permanganate in 4 hours	1.9	5.7	5.1	4.1	2.4	5.1	5.3 (14.2)	11.2	4.7	7.3	5.5	3.5	0.8	0.9	0.9	8.9	2.1	2.8	1.2
6. Ammonia as ppm of Nitrogen	0.11	0.01	0.07	0.08	0.11	0.15	0.17	0	0.09	0.03	0.05	0.06	0.09	0.15	0.07	1.69	0.08	0.06	0.04
7. Nitrite ions as ppm. of Nitrogen	.002	.0036	.001	.0004	.003	.005	.002	.0003	.0011	.0165	.0094	.026	.001	.0021	.0016	.23	.01	.004	.002 (.007)
8. Nitrate ions as ppm. of Nitrogen	.06	.018	.013	.034	.038	.02	.038	.026	.042	.30	.06	.022	.02	.03	.02	1.25	.036	.01 (.03)	.01 (.06)
9. Sulphate ions in ppm.	2.2	14.8	8.3	10.5	1.9	32.5	5.2	57.6	4.2	2.5	4.8	5.9	1.7	1.7	1.9	29.8	2.1	1.8	1.9
10. Chloride ions in ppm.	3.6	11	16	20	4.5	9.3	5.4	12	4.4	3.7	4.7	6.1	2.3	2.8	3.0	586	5.7	5.7	7.2
11. Alkalinity in ppm.	54	352	416	376	68	75	77	92	69	46	67	74	45	46	46	225	48	50	56
12. Calcium (as ppm. Calcium carbonate)	21	103	63	77	21	82	35	36	31	21	29	32	20	20	21	190	23	24	28
13. Magnesium (as ppm Calcium carbonate)	19	123	191	208	27	21	24	25	25	25	23	26	15	14	16	244	16	20	21
Mean percent saturation of dissolved oxygen during day	93			86	90	87	(32) 84	90	91	59	74	95	94	93	94	89	100	91	97
at dawn	81						63				27	68							

Note: (1) Figures in brackets represent exceptional values discussed in the text.

(2) Values of analysis of effluents entering the river have been tabulated one line below analyses on the main river.

TABLE 3.

<u>The range of variation in conditions during the dry season (May - October, 1956) in the Little Bushmans and Bushmans Rivers</u>

								STATIONS							STATIONS				
	1	2	3	4	5	6	7	19	8	9	10	11	12	13	14	15	16	17	18
1. pH.	6.7-7.5	7.3-7.8	7.8-8.0	7.5-7.8	7.3-7.6	7.3-10.2	7.4-8.0	7.2-9.3	7.7-8.0	6.8-7.3	7.0-7.3	7.3-8.1	6.8-7.5	6.9-7.6	7.0-7.5	7.2-8.1	7.0-7.7	7.0-7.6	6.9-8.2
2. Electrical Conductivity mmhos.	57-144	390-610	680-890	390-650	76-180	101-425	68-198	126-1210	76-180	54- 92	76-190	85-270	56- 76	58- 79	59- 83	680-2900	65- 95	45-106	36-135
3. Total Dissolved Solids in ppm.	46- 90	392-414	441-670	301-458	68-115	78-194	61-207	101-1046	80-120	69- 80	82-126	56-135	53- 67	58- 73	46- 69	932-1830	52- 72	50-113	53- 97
4. 5-Day Biochemical Oxygen Demand at 20°C in ppm. of Oxygen	0.4-0.9	0.6-1 0	0.5-0.7	0.2-0.8	0.8-1.5	0 -6.2	2.9-73.0	1.6-6.4	2.2-3.9	4.6-30.2	1.9-17.0	2.6-8.9	0.6-0.7	0.5-1.4	0.6-2.4	3.1-9.4	0.8-1.7	0.5-1.0	0.1-1.2
5. Oxygen absorbed from Potassium Permanganate in 4-hrs.ppm.Oxygen	1.0-2.0	0.2-4.0	0.6-2.4	0.4-10.0	1.3-4.5	2.0-12.0	1.6-50.0	0.8-22.2	2.6-11.6	4.2-12.7	2.1-9.0	2.4-4.8	0.2-1.1	0 -1.4	0.4-1.2	1.8-13.4	0.04-4.8	0 -4.2	0.4-1.8
6. Free and Saline Ammonia as ppm. Nitrogen.	0 -0.28	0 -0.03	0 -0.28	0 -0.12	0 -0.45	0 -0.45	0 -0.6	0	0 -0.23	0 -0.06	0 -0.18	0 -0.2	0 -0.23	0 -0.28	0 -0.22	0.9-5.4	0 -0.26	0 -0.17	0 -0.17
7. Nitrite as ppm. Nitrogen.	.001-.005	0 -.01	0 -.002	0 -.001	.001-.006	.001-.012	0 -.004	0 -.001	0 -.003	0 -.08	0 -.02	.001-.12	0 -.002	.001-.005	0 -.003	.08-.56	.001-.028	.001-.005	.001-.004
8. Nitrate as ppm. Nitrogen.	.02-.15	0 -.04	0 -.03	0 -.08	.02-.06	0 -.04	0 -.06	.01-.04	.02-.06	.01-1.4	.04-.10	0 -.04	0 -.06	0 -.06	0 -.06	.24-2.8	0 -.10	0 -.10	0 -.02
9. Sulphate in ppm.	0 - 3	9 - 22	1 - 15	9 - 15	1 -2.8	1.8- 52	3 -16	24.4-128	2.3-5.5	1 -3.4	3.4-5.8	2.5- 10	0 -2.6	1 -2.8	.19-3.2	26- 32	1.5-2.6	0 -3.4	0 -2.8
10. Chloride in ppm.	3 -5.2	7 - 14	14 - 20	14.6- 24	3.2-6.0	4.4-15.6	3.6-8.0	0.4-34.0	2 -5.0	2.8-5.0	3.2-6.6	5 -7.6	0.8-3.8	2.2-3.6	2.4-3.6	301-948	4.6-7.4	4.6-6.8	4.6-9.8
11. Alkalinity as ppm. Calcium Carbonate.	30 - 80	333-380	398-440	301-420	43- 94	67-108	48-128	46-228	48- 90	37- 57	48- 89	50- 99	39- 56	38- 57	39- 58	181-300	40- 61	41- 64	40- 80
12. Calcium as ppm. Calcium Carbonate.	18 - 28	79-132	44- 80	44-106	22- 23	21-107	20- 50	8- 40	21- 41	19- 23	21- 34	23- 40	17- 30	17- 22	18- 24	91-300	18- 25	19- 26	21- 35
13. Magnesium as ppm. Calcium Carbonate.	15 - 25	59-151	152-216	162-257	17- 42	10- 35	16- 34	19- 30	20- 31	13- 38	18- 26	19- 30	11- 17	13- 15	13- 18	102-416	15- 18	17- 24	17- 27
14. Percentage saturation of Dissolved Oxygen.	78 - 99	-	-	72- 99	84-100	74-101	32- 87	73-101	80-105	49- 67	25- 78	58-110	86- 98	83-100	88- 97	65-108	91-106	86- 98	84-104

The effects of pollutants on conditions in the Bushmans and Little Bushmans Rivers

(a) Little Bushmans River

	Level of Concentration in river above Pollution	Changes in concentration occurring in Sections between stations on the Little Bushmans river				
		Changes in Sections between Stations				
		1 - 5	5 - 7	7 - 8	8 - 10	10 - 11
Rate of Flow in cusecs.	4	0.12	0.18	0.025	0.65	?
Effluents Entering		Disposal Farms (2,3,4)	Board-Mill Boiler House (6)	Board-Mill Drain (19)	Milk-Processing Factory (9)	Town Drains -
Total Dissolved Solids in ppm.	71	17	47	-27	-3	13
ppm. Oxygen absorbed from Permanganate in 4 hours	1.9	0.5	2.9 (11.8)*	-0.6	0.8	-2.0
5-day B.O.D. at 20°C in ppm. Oxygen	0.7	0.4	3.6 (20.7)*	-1.6	5.1	-2.0

(* When the September high values are included)

(b) Bushmans River

	Level of Concentration in river above Pollution	Changes in concentration occurring in sections between stations on the Bushmans river				
		Changes in Sections between Stations				
		12 - 13	13 - 14	14 - 16	16 - 17	17 - 18
Rate of Flow in cusecs	59.3	-	-	4.98	1.0	?
Effluents Entering	-	-	Little Bushmans river (11)	Sewage Farm	-	-
Total Dissolved Solids in ppm.	60	6	-1	4	7	7
ppm. Oxygen absorbed from Permanganate in 4 hours	0.8	0.1	0	1.2	0.7	-1.6
5-day B.O.D. at 20°C. in ppm. Oxygen	0.7	0.1	0.6	-0.2	-0.4	-0.1

TABLE 5

ANALYSES OF SEDIMENTS

RESULTS CALCULATED AS PERCENTAGE OF DRY WEIGHT

	Sediments		
	Below Board-Factory, Station 7	Below Board-Factory, Station 19	Below Milk-Processing Factory, Station 9
Moisture	66.82	90.67	48.66
Ash	14.4	58.0	8.3
Free and Saline Ammonia as N.	* 6.3×10^{-4}	7.5×10^{-4}	13.7×10^{-4}
Organic Nitrogen as N.	974×10^{-4}	258×10^{-4}	3360×10^{-4}
Inorganic Carbon as C.	0.087	0.39	0.21
Organic Carbon as C.	7.16	1.29	2.79
Sulfides as S.	37.5×10^{-4}	180×10^{-4}	Not determined
Oxygen uptake in 5 days per gram dry wt.	1.2	1.35	-

* (NOTE: 6.3×10^{-4}. % = 6.3 ppm.)

TABLE 6

SYNOPSIS OF CONDITIONS IN UNPOLLUTED PARTS OF THE BUSHMANS AND LITTLE BUSHMANS RIVERS.

	Average mid-Season Temperature °C	Average Monthly Rate of Flow Cusecs.		Concentration of Dissolved Solids in ppm.		4-hour O.A. (Permanganate). ppm. oxygen		5-day B.O.D. at 20°C ppm. oxygen	
		Little Bushmans River.	Bushmans River.	Little Bushmans River.	Bushmans River.	Little Bushmans River.	Bushmans River.	Little Bushmans River.	Bushmans River.
Summer Wet Season	20	30	333	37	103	0.3	1.4	0.9	0.9
Winter Dry Season	8	4	63	71	118	1.9	0.8	0.7	0.7

TABLE 7a

THE AVERAGE NUMBERS OF SIGNIFICANT SPECIES IN THE DRY SEASON, IN 3 SQUARE FEET OF STONY BOTTOM IN RAPIDS, UNDER DIFFERENT CONDITIONS.

(Percentage composition indicated in brackets)

Species[*]	Type	Normal Conditions	Conditions of Contamination		
			Light	Medium	Heavy
FLORA :					
Cladophora sp.		-	-	++	-
Oscillatoria spp.	+	-	+	++	++
Oscillatoria angustissima W. & G.S. West		-	+	++	++
Oedogonium spp.		s	+	-	+
Phormidium truncatum LEMM	+	-	+	++	+++
Stigeoclonium spp.	+	-	+	+	++
Stigeoclonium tenue W.G.		-	+	+	++
Spirogyra spp.	+	s	+	++	++
Wet bulk of all species of algae ccs. per sq. ft.	+	5	15	50	150
FAUNA :					
Planaria? sp. 1.		10(.3)	30 (.6)	200 (3)	0
Sorocelis? sp. 1.	+	0	0	0	250 (.8)
Microstomium sp. 1.	+	0	0	0	350 (1.2)
Nygolaimus? sp. 1.	+	10 (.3)	300 (6)	350 (5)	1,000 (3)
Chaetogaster sp. 1.	+	50 (1.5)	1,000 (20)	2,000 (30)	2,000 (7)
Nais sp. 1.	+	50 (1.5)	600 (12)	1,500 (22)	18,000 (60)
Stylaria sp. 1.		100 (3)	900 (18)	0	10
Limnodrilus sp. 1.	+	5 (.2)	90 (2)	-	900 (3)
Glossiphonia sp. 1.	+	0	0	0	300 (1)
Alona cambouei	+	1	3	-	200 (.7)
Paracyclops poppei (Rehberg)	+	0	30 (.6)	50 (.7)	6,000 (20)
Baëtis harrisoni Barnard	-	350 (11)	300 (6)	500 (7)	0
Euthraulus elegans Barnard	-	200 (6)	50 (1)	100 (1)	0
Hydropsyche ulmeri Barnard	-	6 (.2)	10	35 (.5)	0
Cheumatopsyche zuluensis (Barnard)	-	20 (.6)	2	9	0
Simulium spp.	-	1,300 (39)	800 (16)	11 (.2)	0
Orthocladiinae sp. 3.	+	1	60 (1)	260 (4)	300 (1)
O. sp. 5.	+	900 (27)	600 (12)	700 (10)	70 (.2)
Chironominae sp. 1.	+	10 (.3)	100 (2)	500 (7)	600 (2)
Tanytarsus sp. 1.	-	300 (9)	120 (2)	300 (4)	0
Burnupia sp. c.f. ponsonbyi Walker	+	0	20 (.4)	200 (3)	0
Total numbers of individuals		3,313	5,015	6,715	29,980

(See notes at foot of Table 7c).

TABLE 7b

THE AVERAGE NUMBERS OF SIGNIFICANT SPECIES IN TEN FEET OF MARGINAL VEGETATION, IN THE DRY SEASON, UNDER DIFFERENT CONDITIONS.

(Percentage composition indicated in brackets)

Species[x]	Type	Normal Conditions	Conditions of Contamination		
			Light	Medium	Heavy
FLORA :					
Oscillatoria spp.	+	-	+	++	++
Phormidium truncatum Lemm	+	-	+	-	+++
Spirogyra spp.	+	•	+	++	+++
The Wet Bulk of All Species of algae (in cc. per foot)	+	1	15	40	150
FAUNA :					
Sorocelis? sp.	+	0	40 (.2)	2	4,700(1)
Microstomium sp. 1.	+	0	15	0	240,000 (64)
Nygolaimus? sp. 1.	+	10 (1)	4,000 (21)	3,000 (12)	27,000 (7)
Chaetogaster sp. 1.	+	30 (4)	2,000 (11)	13,000 (51)	6,000 (2)
Nais sp. 1.	+	80 (10)	600 (3)	2,000 (8)	50,000 (13)
Limnodrilus sp. 1.	+	0	150 (1)	0	4,000 (1)
Simocephalus vetuloides (Sars)	+	2	150 (1)	1,300 (5)	500 (.1)
Alona cambouei	+	0	800 (4)	900 (4)	10,000 (3)
Alona guttata Sars	+	0	0	0	1,000 (.3)
Chydorus gibsoni Brady		0	10,000 (53)	3,000 (12)	240
Pleuroxus aduncus (Jurine)	+	0	130 (.7)	-	2,400 (.6)
Macrocyclops albidus (Jurine)	+	7 (1)	50 (.3)	700 (3)	200
Eucyclops euacantus (G.O. Sars)	+	50 (7)	300 (2)	120 (.5)	1,400 (.4)
Paracyclops poppei (Rehberg)	+	0	24 (.1)	-	25,000 (7)
Pseudocloeon vinosum Barnard		60 (8)	30 (.2)	500 (2)	0
Baetis bellus Barnard	-	70 (9)	95 (.5)	90 (.4)	0
Baetis sp. 2.	-	25 (3)	0	0	0
Pseudagrion salisburyense Ris	+	13 (2)	10	70 (.3)	50
Berosus sp. 1.	-	7 (1)	7	1	0
Orthocladiinae sp. 3.	-	100 (13)	40 (.2)	250 (1)	0
O. sp. 5.	-	130 (17)	48 (.3)	500 (2)	0
Chironominae sp. 2.	-	180 (24)	510 (3)	150 (.6)	0
Total numbers of individuals		764	18,999	25,583	372,490

(See notes at foot of Table 7c).

T A B L E 7c

THE AVERAGE NUMBERS OF SIGNIFICANT SPECIES IN 9 SQUARE INCHES OF BOTTOM SEDIMENTS, IN THE DRY SEASON, UNDER DIFFERENT CONDITIONS.

(Percentage composition indicated in brackets)

Species*	Type	Normal Conditions	Conditions of Contamination		
			Light	Medium	Heavy
FLORA :					
Oscillatoria spp.	+	s	+	++	++
Phormidium sp.	+	s	+	++	++
Spirogyra spp.		+	+	++	+
FAUNA :					
Sorocelis? sp. 1	+	0	0	5 (2)	130 (4)
Microstomium sp.	+	0	0	1 (.3)	500 (14)
Nygolaimus? sp.	+	6 (7)	63 (33)	60 (19)	600 (17)
Chaetogaster sp. 1.		8 (10)	50 (26)	150 (48)	20 (.6)
Nais sp. 1.	+	0	4 (2)	6 (2)	900 (25)
Limnodrilus sp. 1.	+	2 (2)	30 (16)	50 (16)	1,200 (34)
Branchiura sp. c.f. soverbyi Bedd.	+	1 (1)	0	2 (.6)	40 (1)
Paracyclops poppei (Rehberg)	+	6 (7)	1 (.5)	2 (.6)	150 (4)
Austrocaenis capensis Barnard	-	9 (11)	8 (4)	2 (.6)	0
Procladius spp. 1 & 2		1 (1)	5 (3)	10 (3)	0
Orthocladiinae sp. 5.	-	4 (5)	3 (2)	7 (2)	2
Chironominae sp. 4.	-	12 (15)	10 (5)	11 (3)	0
Tanytarsus sp. 1.	-	30 (37)	13 (7)	8 (3)	0
Ceratopogonidae sp. 7.	-	3 (4)	4 (2)	1 (.3)	0
Total numbers of individuals		82	191	315	3,542

S Y M B O L S

+ indicates that the numbers are positively correlated with contamination.

- indicates that the numbers are negatively correlated with contamination.

Quantities.

s indicates sparsely present, less than approximately 10 c.c. wet volume per sample unit.

+ indicates small quantities of approximately 10 - 50 c.c. per sample.

++ indicates medium quantities of approximately 50 - 200 c.c. per sample.

+++ indicates large quantities, over approximately 200 c.c. per sample unit.

*NOTE : Numbers have been given to species which could not be named, but which were separated with some certainty. It is hoped that these will be identified later.

TABLE 6

The zonation observed in the Bushmans and Little Bushmans Rivers compared with European and American systems of classification.

System of Classification:	ZONES			
According to:				
Kolkwits & Marrson (1908)	Oligosaprobic	. Mesosaprobic	. Mesosaprobic	Polysaprobic
Forbes & Richardson (1913)	Clean water	Recovery Zone	Contaminated zone	Septic
Butcher, Longwell & Pentlow (1937)	Normal water	Pollution	Pollution	Serious Pollution
Butcher (1947)	Repurified Water	Mild pollution	Pollution	Foul Pollution
Gaufin & Tarzwell (1956)	Clean Water	Recovery zone	Recovery zone	Septic

Grades of Contamination recognised in the Bushmans River

	Nil	Slight	Medium	Heavy	Foul
Identification numbers of Stations on the Bushmans river system	12 1 18	14 5	16	8 (7 toxic) 11	10 ? Sludge Beds

TABLE 9

The average numbers of Individuals in 3 square feet of Stones in Rapids during the dry season.
Percentage composition of the average fauna at each station given in brackets.

Order & Family	Species	Stations on the Little Bushmans River						Stations on the Bushmans River				
		1.	5.	7.	8.	10.	11.	12.	14.	16.	17.	18.
Coelenterata: Hydridae:	Hydra sp.1.	78x(1)	18x(.3)				228x(.5)				18x(.6)	
	Hydra sp.2.							6x	6x	15x(.2)	15x(.5)	
Turbellaria: Planariidae:	Dugesia? sp. / Planaria? sp.	13(.2)	226(4)				74	4(.3)	31(1)	184(3)	56(2)	4
Dendrocoelidae:	Sorocelis? sp.1.				252x(1)	252x(1)						
Rhabdocoela:	Microstomium sp.1.				24x(.1)	360(1)	18x					
Nematoda: Diplogasteridae:	Diplogaster?sp.1.								3x			
Dorylaimidae?	Nygolaimus? sp.1.	2	40(.6)	276(2)	2328(11)	1038(4)	1854(4)	22(2)	570(15)	122(2)	21(.7)	6x(.3)
Oligochaeta: Aeolosomatidae:	Aeolosoma beddardi? Michaelsen							2x				
Naididae:	Chaetogaster sp.1.	91(1)	462(7)	929(8)	2205(11)	468(2)	1014(2)	10x(1)	1683(45)	1782(25)	21(.7)	12(.5)
	Nais sp.1. (or spp.)	99(2)	837(13)	9466(77)	13302(64)	17556(63)	16446(38)	10(1)	344(9)	1484(21)	76(2)	100(4)
	Nais sp.2.						24x	5x			6x	
	Stylaria sp.1.	114(2)	912(14)	108(1)	48(.2)	12x	3306(8)					17(.7)
	Dero limosa? Leidy								3x			
	Aulophorus furcatus (Oken)			528x(4)		24x						
	Naidium sp.1.			24x(.2)	24x(.1)		864x(2)	5		6x		33(1)
	Pristina sp.1.								3x			6x
Tubificidae:	Tubifex sp.2.					11x						
	Limnodrilus sp.1.	12x(.2)	94(1)	573(5)	654(5)	852(3)	1195(3)	2	3x			3x
Limbriculidae:	Lumbriculidae sp.1.						1	1				
Hirudinea: Glossiphoniidae:	Glossiphonia sp.1.					289(1)	124(.3)					
Cladocera: Daphniidae:	Simocephalus vetuloides (Sars)	6x	18x(.3)				5100x(12)		3x			
	Ceriodaphnia quadrangula (Müller)	12x(.2)			24x(.1)					12x(.4)		

TABLE 9 (Continued)

Order & Family	Species	Stations on the Little Bushmans River 1.	5.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.	18.
Cladocera Bosminidae:	Bosmina longirostris (Müller)	12m(.2)										
Macrothricidae:	Macrothrix propinqua Sars						108m(.3)		3m			
	Ilyocryptus sordidus (Lièvin)		6m									
Chydoridae:	Leydigia microps Sars		24m(.4)						3m			
	Alona cambouei (Müller)				48m(.2)	204(.7)	378m(.9)	2m	6m			
	A.sp.cf. quadrangularis (Müller)	6m	114(2)				336m(.8)		3m	24m	30m(1)	
	Chydorus gibsoni Brady		30m(.5)				4200m(10)		24(.6)	24m(.3)	18m(.6)	
	Pleuroxus aduncus (Jurine)		24m(.4)				924m(2)			3m	21m(.7)	12m(.5)
Copepoda: Cyclopidae	Macrocyclops albidus (Jurine)								3m			
	Eucyclops euacantus (Sars)								3m			
	Paracyclops fimbriatus (Fisher)	6m										
	P. poppei (Rehberg)		54m(.8)	7	1320(6)	5670(20)	3168(7)			48m(.7)	12m(.4)	
	Elaphoidella bidens decorata (Sars)	30m(.5)	42(.7)				[illegible]				18m(.6)	
Ostracoda: Cyprididae:	Eucypris sp. 1.		2m					2m	3m			9m(.4)
	Cypretta arcuata?	6m										
	Zonocypris sp. 1.			4m						24m(.3)		
	Ilyocypris australiensis? Sars										6m	24(1)
	Cypridopsis reniformis Sars									197m(3)		
	C.hirsuta?		138m(2)							3m	3m	12m(.5)
Hydrachnellae:	Various species.	2m	6m					9	30(.8)	12m(.2)	30(1)	9(.4)

TABLE 9 (Continued)

Order & Family	Species	Stations on the Little Bushmans River						Stations on the Bushmans River				
		1.	5.	7.	8.	10.	11.	12.	14.	16.	17.	18.
Plecoptera: Perlidae:	Neoperla spio (Neuman)							4	7		1	1
Ephemeroptera: Prosopistomatidae:	Prosopistoma crassi								4	1m	17(.6)	
Baetidae:	Pseudocloeon maculosum Crass							35(3)	15m(.4)	24(.3)	40(1)	34(1)
	P. vinosum Barnard								3m			
	Baetis harrisoni Barnard	472(7.6)	241(4)	10m		6m	247m(.6)	129(11)	196(5)	488(7)	384(12)	368(15)
	B. sp. 1.							11(1)		1	34(1)	54(2)
	Centroptilum sudafricanum Lest	14(.2)							14(.4)		16(.5)	6m
	C. excisum Barnard		12(.2)				1m		3m		15(.5)	
	C. indusii Crass							1	8	6	13(.4)	4m
	C. sp. 2							1				2
	C. parvum Crass											2m
	C. ? sp.											30(1)
Brachycercidae:	Caenis sp. 2.	25(.4)	13(.2)					39(3)	57(2)	9	161(5)	122(5)
	Caenis sp. 3.	45(.7)						23(2)	17(.4)	19(.3)	31(1)	2m
	Neurocaenis discolor (Barnard)	14(.2)						9	1	6	4	
Leptophlebiidae:	Adenophlebia auriculata Eaton								1			
	Euthraulus elegans Barnard	272(4)	35(.5)					99(9)	60(2)	116(2)	353(11)	501(21)
Ecdyonuriidae:	Afronurus sp. 1.							77(7)	35(1)	31(.4)	35(1)	33(1)
Odonata: Chlorocyphidae:	Chlorocypha sp. 1.							5				
Gomphidae:	Paragomphus cognatus Ramb.	1										
Aeshnidae:	Aeshna rileyi McL.	1	1						1		1	
Libellulidae:	Zygonyx sp. 2.									1m	1	1m
Trichoptera: Hydropsychidae:	Hydropsyche ulmeri Barnard	2	5					10(1)	14(.4)	35(.5)	10(.3)	24(1)

TABLE 9 (Continued)

Order & Family	Species	Stations on the Little Bushmans River						Stations on the Bushmans River				
		1.	5.	7.	8.	10.	11.	12.	14.	16.	17.	18.
Trichoptera: Hydropsychidae:	H. sp. 1.									6	20(.6)	6
	Cheumatopsyche maculata (Mosely)	1										
	C. triangularis (Ulmer)											3m
	C. zuluensis (Barnard)							41(4)	4	9	105(3)	307(13)
Polycentropidae:	?Dipseudopsis sp. 1.							5m	6		3m	
Psychomidae:	?Ecnomus sp. 1.								8		10(.3)	
Hydroptilidae:	Hydroptila capensis (Barnard)						1m		8		13(.4)	
	H. sp. 1.									24m(.3)	6m	3m
Lepidoptera: Pyralididae:	Nymphula? sp. 2.									1		
Coleoptera: Gyrinidae:	Gyrinidae larvae	93(1)	11(.2)					2	2m		1	
Hydrophilidae:	Berosus sp.									3m		
Psephenidae:	Eubrianax										1	
Hydraenidae:	Ochthebius? sp. 3.	13(.2)							3m			
	O. sp. 4.	6m										
Elmidae:	Elmidae sp. 1.		11m(.2)					4	12(.3)	6	30(1)	2
	sp. 3.							5m		5m	1	1
	sp. 4.							1	1m			
	sp. 8.									30m(.4)	6	
	sp. 9.		1m								3m	
	sp.10	3						2				
	sp.11.	2m										
	sp.12.									6m		
	sp 13.	12(.2)										
	sp.14		2m									3m

TABLE 9 (Continued)

Order & Family	Species	Stations on the Little Bushmans River 1.	5.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.	18.
Diptera Psychodidae:	?Pericoma sp. 2.					3*						
Blepharoceridae:	Elporia flavopicta Edwards											1
Simuliidae:	Simulium medusaeforme forma africanum Gibbins	6*									3*	
	S. schoutedeni Wanson	[illegible]										
	S. spp.	2508(40)	1562(24)					160(14)	15(.4)	11(.2)	290(9)	20(.8)
	S. nigritarsis Coquillet	*	*					*	*	*	*	*
	S unicornutum form rotundum Gibbins										1	
Chironomidae:	Pentaneura sp. 1.	42*(.7)	25(.4)	32(.3)				12(1)			3	14(.6)
	P. sp. 2.	1	31(.5)		28(.1)					26(.4)	15(.5)	2*
	P. sp. 7.							4*			6*	18(.8)
	P. sp. 8.		60(.9)							30(.4)		6*
	Procladius sp. 1 and 2				12							
	Orthocladiinae sp. 1.							10*(1)	6*		120*(4)	122(5)
	O. sp. 2.							2*		71(1)		
	O. sp. 3.		24*(.4)	151(1)	96(.5)	311(1)	1643(4)	2*	95(3)	256(4)	82(3)	165(7)
	O. sp. 4.		6*				18*	10(1)		62(1)		
	O. sp. 5.	1535(25)	956(15)	221(2)	48(.2)	74	125(.3)	243(21)	189(5)	736(10)	416(13)	109(5)
	Chironominae sp. 1.	19*(.3)		26(.2)	313(2)	552*(2)	1224(3)		195(5)	499(7)	111(4)	11(.5)
	C. sp. 2.	[illegible]	61(1)	7*	8*		21*	10(1)		18(.2)	32(1)	6*
	C. sp. 4.	77*(1)							9	9*	7	5*
	C. sp. 5.	6*	6*					2*		54(.7)	30(1)	13*(.5)
	C. sp. 6.									90*(1)		
	C. sp. 7.									6*		
	C. sp. 8.								3*			
	C. sp. 9.	6*						3*	6*			
	Chironomidae: sp. 4.				[illegible]							
	C. sp. 5.									6*		9
	C. sp. 6.					53	144*(.3)					13(.5)
	C. sp. 7.							6*				
	C. sp. 9.	12*(.2)										
	C. sp.10.									6*		

TABLE 9 (Continued)

Order & Family	Species	Stations on the Little Bushmans River 1.	5.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.	18.
Diptera: Chironomidae:	Tanytarsus sp. 1.	472(8)	231(4)					79(7)	6	299(4)	160(5)	67(3)
	T. sp. 3.											6■
	T. sp. 4.	78(1)	18■(.3)					2■			18(.6)	6■
	T. sp. 5.						9■			5■	6■	
	T. sp. 6.								3■		6	1■
	Rheotanytarsus sp. 1.									63(.9)	3■	
Ceratopogonidae:	Ceratopogonidae sp. 1.					3■		5■		6	30(1)	9■(.4)
	C. sp. 7.							2■	2■		12■(.4)	
	C. sp. 8.											6■
Rhagionidae:	Atherix sp. 1.		14(.2)	6■				20(2)	1	11(.2)	3	
Tabanidae:	Haematopota?sp. 1.		9■(.1)	1	3■		1				5	8(.3)
Empididae:	Argyra sp. 1.							3■		8■	6■	
	Hemerodromia sp. 2.									3■		
Anthomyiidae:	Limnophora sp. 1.						1■			1		
Gasteropoda: Ancylidae:	Burnupia sp.c.f. ponsonbyi. Walker		15(.2)						29(.8)	205(3)	64(2)	1■
	Ferrissia sp. 1.			4■								
Anura: Bufonidae:	Bufo sp.				12■							2■
	Total numbers of individuals	6241	6397	12373	20757	27738	42815	1158	3766	7236	3107	2376

■ Present on one occasion only.

T A B L E 1 0

The average numbers of Individuals in 10 feet of Marginal Vegetation during the dry season.

Order & Family	Species	Stations on the Little Bushmans River 1.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.	18.
Colenterata Hydridae:	Hydra sp. 1.					40*	1*	4*	2*	4*	
Turbellaria: Planariidae:	Planaria? spp.							13		8*	4
Dendrocoelidae:	Sorocelis? sp. 1.				4680(1)	960*(.4)		43*(.2)	2*		
Rhabdocoela:	Microstomium sp. 1.		636(8)	984*(1)	240700(64)	1920*(.9)		13		8*	
Nemertea: Prostomiidae:	Prostoma? sp.							11*		4*	
Nematoda: Dorylaimidae:	Nygolaimus? sp. 1.	8*(.6)	3004(36)	23692(33)	26715(7)	43887(20)	14(3)	3925(20)	3154(11)	1320(13)	7(.7)
Tardigrada: Tardigrada:	Tardigrada sp. 1.							40*(.2)			
Oligochaeta: Naididae:	Chaetogaster sp. 1.	52(4)	1752(21)	3652(5)	5756(2)	24312(11)	5*(1)	2208(12)	12842(46)	376(4)	28(3)
	Nais sp. 1. (or spp.)	161(11)	1480(18)	31890(45)	51310(14)	19418(9)	4*(.8)	589(3)	1982(7)	488(5)	27(3)
	Dero limosa? Leidy					480*(.2)					
	Aulophorus furcatus (Oken)		104*(1)								
	Naidium sp. 1.					16*	7*(1)	3*	14*	4*	-
Tubificidae:	Limnodrilus sp. 1.		144*(2)	2016*(3)	4235(1)	1936(.9)	-	152(.8)	-	4*	18*(2)
	Branchiura sp.c.f. sowerbyi Bedd									8*	
Cladocera: Daphniidae:	Simocephalus vetuloides (Sars)		24*	12*	480*(.1)	10093(5)	4*(.8)	145(.8)	1336(5)	140(1)	
	S. capensis (Sars)					12*					
	Ceriodaphnia quadrangulis (Muller)		8*	12*				16*		120(1)	4*
Macrothricidae:	Macrothrix propinqua Sars				80*	314					
	Ilyocryptus sordidus ([illegible])							3*			4*
Chydoridae:	Leydigia quadrangularis (Leydig)							3*			

TABLE 10 (Continued)

Order & Family	Species	Stations on the Little Bushmans River					Stations on the Bushmans River				
		1.	7.	8.	10.	11.	12.	14.	16.	17.	18.
Chydoridae:	Alona cambouei (Müller?)		8m	2304m(3)	9560(2)	22944(10)		768(4)	864m(3)	408m(4)	
	Alona sp.c.f. affinis (Leydig)										2m
	A. sp. cf. quadrangularis (Müller)							3m			6m(.6)
	A. guttata Sars				900m(.2)	576m					
	Chydorus gibsoni Brady			1812m(3)	240m	67476(31)		9573(50)	3000(11)	4460(45)	
	Pleuroxus aduncus (Jurine)			1476m(2)	2411(.6)	8124(4)		127(.7)		88m(.9)	2m
Copepoda: Cyclopidae:	Macrocyclops albidus (Jurine)				211m	48m	14'3)	48(.3)	704(3)	176(1.8)	
	Tropocyclops confinis Kiefer	100m(7)				72	29(6)	221(1)		108(1)	15m(1)
	Eucyclops euacantus (Sars)	104(7)	102(1)	1992m(3)	1440m(.4)	48m	1m	309(2)	120m(.4)	588(6)	2m
	Eucyclops sp.c.f. sublaevis Sars						6m(1)				30m(3)
	Thermocyclops schuurmanae Kiefer				68m						
	Eucyclops sp.c.f. speratus (Lilljeborg)		32m			132		6m	84m		1m
	Paracyclops poppei (Rehberg)		962(12)	1240(2)	25165(7)	13608(6)		24m(.1)			59(6)
	Cyclops sp.cf. varicans Sars						1m				
	Mesocyclops leuckarti (Claus)					720m				20m	
	Elaphoidella bidens decorata (Sars)					240m		5m		24	6m
Ostracoda: Cyprididae:	Eucypris sp. 1.								48m		5
	Cypria capensis (Sars)										4m
	Cyprilla arcuata Sars										4m
	Cypretta minna (King)										4m
	Ilyocypris australiensis (Sars)										6
	Herpetocypris? cheuvreusii (Sars)									4m	
	Cypridopsis glabrata Sars									538m(5)	
	C. hirsuta Sars										6m
	C. reniformis Sars							9			4m

TABLE 10 (Continued)

Order & Family	Species	Stations on the Little Bushmans River					Stations on the Bushmans River				
		1.	7.	8.	10.	11.	12.	14.	16.	17.	18.
Decapoda: Potamonidae:	Potamon sidneyi Rathburn					1*					
Hydrachnellae:	Hydrachnellae:		4*				1*		40*	16*	
Ephemeroptera: Baetidae:	Austrocloeon africanum Barnard								48*		
	A. virgiliae Barnard	4							1*		
	Pseudocloeon vinosum Barnard	14(1)					108(21)	32(.2)	520(2)	188(2)	161(16)
	Baetis harrisoni Barnard	22(2)					1				
	B. bellus Barnard	30(2)					102(20)	95(.5)	91*(.3)	12	20(2)
	B. sp. 2.	48(3)									14(1)
	B. sp. 1.										8
	Centroptilum excisum Barnard		4*				4(.8)		37	23	28(3)
	C. indusii Crass										1
	C. venustrum Barnard	1*						4*	16	1*	8*(.8)
Brachycercidae:	Austrocaenis capensis Barnard	10(.7)					27(5)	16	102(.4)	84(.9)	138(13)
	Caenis sp. 3.										3
Leptophlebiidae:	Euthraulus elegans Barnard						1*				
Odonata: Lestidae:	Lestes plagiatus Burm									1*	
Coenagriidae:	Pseudagrion natalense Ris						1				
	P. salisburyense Ris	13(.9)	13*	8	54	19	13(2)	9	72	18	8(.8)
Aeshnidae:	Aeshna rileyi Calvert								1*		
Libellulidae:	Trithemis sp.					1*				14	
Hemiptera: Veliidae:	Rhagovelia nigricans Burm	9(.6)					1*	22(.1)			
Notonectidae:	Enithares sobria Stål					242		1			
	Anisops varia? Fieb			1*			1*	2*	1*		
Pleidae:	Plea pullula Stål									2*	
Corixidae:	Micronecta picinnin Hutch							4*	96*	2*	
Naucoridae:	Laccocoris limnigenus Stål	1*						1*			1*

TABLE 10 (Continued)

Order & Family	Species	Stations on the Little Bushmans River 1.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.	18.
Hemiptera: Nepidae:	Nepa sp.c.f. cinerea L.										1*
Belostomidae:	Sphaerodema nepoides Fabr.							1*			
Trichoptera: Leptoceridae:	Athripsodes harrisoni Barnard						6(1)		1	4*	
	sp. 1.						3	23(.1)		6	
Hydropsychiidae:	Cheumatopsyche sp.								12*		
Lepidoptera: Pyralididae	Nymphula? sp.									8*	
Coleoptera:	Dytiscidae larvae spp.	1*		12*		240			12		
	Guignotus harrisoni O-C			1*	1*			1*			
	Laccophilus lineatus Aubé					1*		1*			
	Potamonectes vagrans O-C								1		
Gyrinidae:	Gyrinidae larvae spp.	3									
	Gyrinus natalensis Rég.									1*	
	Aulonogyrus abdominalis Aubé	1									
	A. sesotho Brinck									1*	
Hydrophilidae:	Hydroporus? sp.	16(1)									
	Berosus sp.						2	3*			4*
	Berosus sp. 1.	2*	4*				11(2)	7	1	7	8(.8)
Hydroscaphidae:	Hydroscaphidae sp. 1.	2									1
Hydraenidae:	Ochthebius sp. 1.	5			1		1	9	2*		
	O. sp. 3.	8*(.6)						3*			
	O. sp. 5.	8*(.6)									
Elmidae:	Elmidae sp.	1*									
	E. sp.14.								14*		
Diptera: Tipulidae:	Tipulidae sp.				10*						
Psychodidae:	Psychoda alternata Say		8*								
Diptera: Culicidae:Dixinae:	Dixa sp. 1.						1*	2*			

TABLE 10 (Continued)

Order & Family	Species	Stations on the Little Bushmans River 1.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.	18.
Diptera: Culicidae: Culicinae:	Anopheles sp. 2.	6							48x		
	Culex sp. 2.							3x		8	
Simuliidae:	Simulium spp.	19(.1)					1x				2x
Tendipedidae:	Pentaneura sp. 1.						1x				3x
	P. sp. 2.	2	4	89(0.1)		480x(.2)	6(1)	15	67	129(1)	14(1)
	P. sp. 5.									8x	
	P. sp. 7.	16x(1)				16x	2	11x	13x	97(.9)	2x
	P. sp. 8.	10x(.7)									
	P. sp. 9.							3x			7x(.7)
	Procladius sp. 1 and 2.			8x					2x		
	Orthocladiinae sp. 1.	40x(3)				16x	6x(1)		11x	26x	25(2)
	O. sp. 2.										7x
	O. sp. 3.	186(13)	4x			960x(.4)	12(2)	40x(.2)	246(.9)	52	101(10)
	O. sp. 4.	6x	12x		240x		3x				
	O. sp. 5.	249(17)	4x				9(2)	48x(.3)	494(2)	100(1)	66(6)
	O. sp. 6.										3x
	Chironominae sp. 1.								700x(3)		
	C. sp. 2.	274(19)	8x	20			82(16)	508(3)	150(.5)	92	29(3)
	C. sp. 4.					31x		3x			3x
	C. sp. 5.		4x				3	40x(.2)	17	4x	
	Chironomidae sp. 2.									10x	
	C. sp. 11.							3x			
	C. sp. 12.										4x
	Tanytarsus sp. 1.	17(1)					4x(.8)		48	16	34(3)
	T. sp. 4.						19(4)			28	31(3)
Ceratopogonidae:	Ceratopogonidae sp. 1.						1x		81		9(.9)
	C. sp. 5.		4x				2x	2		16	
Gasteropoda: Planorbidae:	Planorbis sp.c.f. andersoni Ancey									36	1
Gastropoda: Ancylidae:	Burnupia gordonensis (M & P)										1x
	Ferrissia burnupi (Walker)	1x		2x				2x	1x	16	6(.6)
Sphaeriidae:	Pisidium sp. 1.			8x				6x			
Anura: Ranidae:	Rana fuscigula D.B.	1			3x	1	1	1	1x	14	9(.9)
Bufonidae:	Bufo sp. 1.			11x		1x			1008(4)x		30(3)
	Xenopus sp.			11x					2x		
Total numbers of individuals		1451	8329	71253	374,260	219,385	522	19178	28017	9938	1032

x Present on one occasion only.

TABLE 11

The average numbers of Individuals in nine square inches of the Bottom Sediments during the dry season

Order & Family	Species	Stations on the Little Bushmans River 1.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16	17.
Turbellaria: Dendrocoelidae:	Sorocelis? sp.		5m(.8)		128(3)	109m(3)			5(1)	
Rhabdocoela:	Microstomium sp.		8m(1)	43m(2)	533(13)	80m(2)			1m(.3)	
Nematoda: Dorylaimidae:	Nygolaimus? sp. 1.	4(3)	67(10)	242(14)	596(14)	271(8)	8(10)	63(26)	60(16)	31(23)
Tardigrada:	Various species							5m(2)		
Oligochaeta: Naididae:	Chaetogaster sp. 1.	14(9)	15m(2)	11(.6)	19(.4)	20(.6)	3(4)	53(22)	152(41)	
	Nais sp. 1.	1(.6)	13(2)	587(34)	932(22)	225(7)		4(2)	6(2)	
	Nais sp. 2 c.f. obtusa Gerv.		5m(.8)			60m(2)				
	Stylaria sp. 1.				7					
	Dero limosa? Leidy					45m(1)				
	Aulophorus furcatus (Oken)		44(7)		104(3)					
	Naidium sp. 1.		1m			13(.4)	2m(2)			4m(3)
	Pristina sp. 1.			3m						
Tubificidae:	Tubifex sp. 2.				10(.2)	11(.3)				
	Limnodrilus sp. 1.	3(2)	455(71)	702(41)	1229(30)	2037(61)	1(1)	32(13)	47(13)	26(19)
	Branchiura sp. c.f. sowerbyi. Bedd				39(.9)		1(1)		2(.5)	3(2)
Lumbriculidae:	Lumbriculidae sp. 1.						1m(1)			
Hirudinea: Glossiphoniidae:	Glossiphonia sp. 1.				4					
Cladocera: Daphniidae:	Simocephalus vetuloides (Sars)					284(8)		1m(4)		1m(.7)
	Ceriodaphnia pulchella Sars									4m(3)
	C. quadrangula (Müller)									4m(3)
Macrothricidae:	Macrothrix propinqua Sars	8(5)				58m(2)			4m(3)	
	Illyocryptus sordidus (Lièven)					3m				
Chydoridae:	Leydigia microps Sars	5m(3)				11m(.3)				
	Alona cambouei (Muller?)					5m				
	A. sp.c.f. quadrangularis (Muller)	13m(8)							5m(1)	8m(6)

TABLE 11 (Continued)

Order & Family	Species	Stations on the Little Bushmans River					Stations on the Bushmans River			
		1.	7.	8.	10.	11.	12.	14.	16.	17.
	A. striolata Sars	3*(2)								
	Chydorus gibsoni Brady			11*(.6)	272(7)			32*(13)	18(5)	
	C. sp. c.f. sphaericus Müller				48*(1)					
	Pleuroxus aduncus (Jurine)				79(2)					
Copepoda: Cyclopidae:	Macrocyclops albidus (Jurine)	1*(.6)								
	Eucyclops euacantus Sars	2*(1)	5*(.8)	5*(.3)		5*		4(2)	6(1)	
	Thermocyclops schuurmanae Kiefer				2*					
	E. sp.c.f. speratus (Lilljeborg)		5*	3*	2*	22(.7)		1*(.4)	1*(.3)	1*(.7)
	Paracyclops fimbriatus (Fisher)		5*(.8)							
	P. poppei. (Rehberg)	8*(5)	11(2)	117(7)	152(4)	37(1)	4(5)	1*(.4)	2(.5)	8(6)
	Mesocyclops leuckarti (Claus)					3*				
	Elaphoidella bidens decorata (Sars)	6(4)						1*(.4)		1*(.7)
Ostracoda: Cyprididae:	Cypria capensis? Sars								1*(.3)	
	Cyprilla arcuta Sars	11*(7)								
	Cypridopsis hirsuta Sars								1*(.3)	
Hydrachnellae:	Various species								3*(.8)	
Ephemeroptera: Baetidae:	Pseudocloeon vinosum Barnard						4(5)			
	Baetis harrisoni Barnard									1*(.7)
	Centroptilum excisum Barnard	1(.6)					1(1)			
	C. venustrum Barnard						1*(1)			

TABLE 11 (Continued)

Order & Family	Species	Stations on the Little Bushmans River					Stations on the Bushmans River			
		1.	7.	8.	10.	11.	12	14.	16.	17
Brachycercidae:	Austrocaenis capensis Barnard	7(4)					10(12)	8(3)	2(.5)	2(1)
Odonata: Gomphidae:	Paragomphus cognatus Ramb	1(.6)					1(1)			
Trichoptera: Hydropsychidae:	Cheumatopsyche sp.									1m(.7)
Psycheomyidae:	?Economus sp.									2(1)
Coleoptera: Hydrophilidae:	Berosus sp.							1m(.4)		
	Berosus sp. 1.					1m			1(.3)	
	Hydroporus? sp.								1m(.3)	1m(.7)
Elmidae:	Elmidae sp. 1.								1m(.3)	
	E. sp. 4.								1m(.3)	
	E. sp.15.								1m(.3)	
Diptera: Culicidae:	Culicinae:									1m(.7)
Chironomidae:	Pentaneura sp. 2.	4(3)				1	1(1)		1(.3)	
	P. sp. 7.		1m					4(2)	1m(.3)	
	P. sp. 8.	1m(.6)								
	Procladius spp. 1 & 2	1m(.6)				16(.5)	1(1)	5(2)	11(3)	5(4)
	Orthocladiinae sp. 1	4(3)					2(2)	1m(.4)		
	O. sp. 2.								3m(.8)	
	O. sp. 3.		5m(.8)	2m			2(2)			
Diptera: Chironomidae:	Orthocladiinae sp. 4.						1m(1)			
	O. sp. 5.	4(3)			2m		4(5)	3m(1)	7(2)	
	O. sp. 7.								1m(.3)	
	Chironominae sp. 1.	1m(.6)								
	C. sp. 2.						3m(4)		1m(.7)	
	C. sp. 4.	17(11)				7	7(8)	10(4)	11(3)	22(16)
	Chironomus sp. 1.					18(.5)				

TABLE 11 (Continued)

Order & Family	Species	Stations on the Little Bushmans River 1.	7.	8.	10.	11.	Stations on the Bushmans River 12.	14.	16.	17.
Diptera: Chironomidae:	Chironomus sp. 1. (red)					18(.5)				
	C. sp. 2.									1*(.7)
	Chironomidae sp. 3.	1(.6)								
	Tanytarsus sp. 1.	36(23)					18(22)	13(5)	8(2)	3(2)
	T. sp. 4.									1*(.7)
Ceratopogonidae:	Ceratopogonidae sp. 1.						1*(1)		2*(.5)	
	C. sp. 6.	2(1)								
	C. sp. 7.						5(6)	4(2)	1(.3)	3(2)
Rhagionidae:	Atherix sp. 1.						1*(1)			
Tabanidae:	Haematopota? sp. 3.				1*					
Anura: Ranidae:	Rana fuscigula D.B.									1*(.7)
Bufonidae:	Bufo sp. 1.								3*(.8)	
Total numbers of individuals		159	645	1726	4159	3343	83	246	367	136

* Present on one occasion only.

TABLE 12

The bulk of algae (c.c., wet volume) collected per square foot in stones in current

DATE Station No.	8/55	2/56	5/56	6/56	7/56	9/56	11/56	2/57
1	sp.	sp.	sp.	sp.	sp.	(10 sp. veg.)	(25 sp. veg.)	3
5	sp.	sp.	sp.	x	sp.	40	20	13
7	–	–	–	x	150	200	260	20
8	60	–	50	150	75	100	80	17
10	140	–	33	125	225	250	55	20
11	50	0.5	17	–	70	53	37	20
12	15	2	–	sp.	17	7	14	7
14	sp.	3	10	20	38	5	13	8
16	sp.	2	7	40	50	150	7	8
17	2	3	10	8	18	sp.	5	15
18	sp.	–	7	17	4	sp.	3	–

The bulk of algae (c.c., wet volume) collected per five foot of marginal vegetation

DATE Station No.	8/55	2/56	5/56	6/56	7/56	9/56	11/56	2/57
1	sp.	sp.	sp.	sp.	sp.	sp.	(20 sp. veg.)	2.5
7	100	–	600	25	50	–	70	600
8	–	–	–	300	650	1000	250	14
10	–	–	165	300	500	600	290	8
11	–	–	40	–	700	450	600	250
12	sp.	sp.	sp.	sp.	sp.	9	5	7
14	sp.	sp.	sp.	sp.	125	60	30	25
16	65	sp.	sp.	200	180	250	5	20
17	sp.	sp.	sp.	40	85	45	8	5
18	sp.	–	13	20	4	13	17	–

sp = sparse
x = present but quantity not measured
(veg) = little algae, mainly vegetation & detritus

The comparisons of the percentage reductions take no account of water other than the known effluents entering the river between stations. However no significant dilution is known to occur.

Section between Stations	Distance between Stations in miles	Percentage reduction in the 5-day biochemical oxygen demand at 20°C at end of section	Percentage reduction of 5-day BOD per mile in section
7—8	0.5	34	68
10—11	0.8	24	30
16—17	10	33	3.3
17—18	13	12.5	0.9

The sections where the initial high rate of self-purification occurred, were those where the denser and specialised biological associations were found, and so it appears that the river's power of purification was directly related to the density of the community it supported. It must be pointed out that all these observations were made under aerobic conditions; should the river be overloaded, and an anaerobic condition develop, the circumstances could be different.

(d) Subsidiary effects of biological activity:

The amount of dissolved solids found in the river obviously depended upon increments from the effluents and tributaries. However one or two anomalies which have appeared in the analyses are of interest. There was a decrease of 3 ppm. (a load of 64 lbs./day, 29 kg) in the amount of dissolved solids between Stations 8 and 10 as a result of a reduction in concentration of 2 ppm. of bicarbonates, 0.8 ppm. of calcium ions, and 0.5 ppm. of magnesium ions. These reductions could have been due to errors of estimation, or possibly to absorption of material by the communities and sludges of the river, or to precipitation. However, they were probably at least partly a result of the use of free bicarbonates by dense algal growths.

The extent of algal activity can be gauged by the large differences in percentage saturation of oxygen at dawn, and during the day at these stations early in September: The saturation increased from 28% at dawn to 76% at mid-day at Station 10, and from 77% to 110% at Station 11, whereas it increased only from 83% to 99% at Station 1 where there was very little algae.

The slight decrease of 1 ppm. in the concentration of dissolved solids between Stations 13 and 14 on the Bushmans river was probably due to an error of estimation.

(e) Indicators of organic pollution:

(i) Classification: The main reason for studying pollution is to obtain practical methods of detection and control. To achieve these objects the effects of pollution have been typed and classified on various criteria by several different systems. These all have a common basis and have recently been reviewed by HAWKES (1957).

The degrees of pollution recognised in the Bushmans and Little Bushmans river seem to fit previous schemes of classification, and Table 8 indicates the probable equivalence of the zones with those of various authors. In fact one or other of these previous systems could have been adopted, if the chemical and bacteriological conditions in the present study had been better known. As it was not possible to be sure of the exact equivalence of the zones however, a more general system of classification has been adopted to avoid possible confusion. The system is similar to that of Kolkwitz and Marsson, with two degrees of pollution distinguished within the B-Mesosaprobic zone; those of slight, and medium pollution.

A point worth mentioning is the difficulty of typing the zones of organic pollution in practice, because of the intergrading of the zones in any one locality. It is not uncommon to find conditions in the mud typical of foul conditions, conditions in the deeper fringing vegetation typical of heavy contamination, and conditions in the superficial fringe typical of light contamination. In fact this was seen at Stations 7 and 10 on a number of occasions. It is thus important to take the whole river, and all habitats, into account when attempting to classify the degree of pollution generally.

(ii) Comparison with conditons in the Berg river, Cape Province

HARRISON (1958) has recorded conditions under organic pollution in the Berg River, and the Krom stream in the Western Cape Province, which closely parallel those observed in the Bushmans river system in Natal. He distinguished two grades of pollution, light and heavy, which he did not specifically relate to the zones of the saprobic system.

The main features of light organic pollution in the Great Berg and Dwars rivers were firstly, the disappearance of some sensitive species, secondly, the increase in numbers of *Baetis harrisoni*, *Simulium* sp., Chironomidae and Mollusca, and thirdly, the presence of numbers of *Plumatella* sp. and *Nais* sp. All these were features of light contamination in the Bushmans river system. Increased severity of pollution in the Krom river led to increased 5-day Biochemical oxygen demand, reduced percentage saturation of dissolved oxygen, and direct fouling of the surfaces with growths of sewage fungus (*Sphaero-*

tilus sp. etc.) and algae, increased densities of Oligochaeta, especially Tubificidae, and of Copepoda, especially *Paracyclops* sp., the total elimination of many elements, e.g. *Baetis harrisoni*, Chironomidae and *Nais* sp.

(Note: Naturally the 5-day BOD test must be related to actual conditions in the rivers under consideration, for similar numerical values of the test at 20°C, may not relate to similar conditions of the rivers. The average mid-winter, (dry-season) temperature in the Bushmans river was 8°C, and the average winter season temperature was about 12°C, thus the BOD test relates to conditions in the river at an average temperature of about 12°C).

All these changes, with one exception, were observed where pollution was heavy in the Bushmans river. The exception was that a species of *Nais* did not disappear from the Bushmans river. The reason for this may have been that the pollution in the Bushmans was lighter than that observed by Harrison in the Krom river.

The fauna of heavy contamination in the Krom river included numbers of Tubifex sp. and large Oligochaeta (including *Limnodrilus* sp.), *Psychoda alternata* and red *Chironomus* sp. Only one of these species, *Limnodrilus*, was found in the Bushmans system. These species are characteristic of the polysaprobic zone of the Kolkwitz and Marsson system, which was not encountered in the Bushmans river. Thus, the contamination in the Krom seems definitely to have been heavier than that in the Bushmans, and a zone equivalent to the polysaprobic zone appears to have been present.

The features of pollution described by HARRISON (1958) thus appear to apply equally in the Bushmans river system. The particular fauna of heaviest pollution in the Krom river however was not found in the Bushmans, probably because the pollution in this river was not severe enough.

(iii) Indices of pollution:

The question of the detection and assessment of pollution by biological means has been ably presented by HAWKES (1957). He has reviewed the findings of a number of well known American and European surveys, and he concludes that the ideal system of assessment takes into account the effect of pollution on the whole range of species within the several communities of a stream.

The associations described in this study have proved to be clear indicators of conditions in the rivers, and as the effects of organic pollution seem to be much the same everywhere, the specialised communities of pollution can safely be regarded as indices of pollution.

It is however, differences between normal and specialised com-

munities which are especially significant, and these differences, in conjunction with changes in physical and chemical conditions, albeit small, are safe and clear indicators of the degree of organic pollution, to which the community in the river is subjected.

Acknowledgements

A study of this nature naturally relies to a great extent upon the helpful co-operation of many different workers, and it is fitting again gratefully to acknowledge the assistance of the many experts mentioned in Part I of the series. In addition, the author particularly wishes gratefully to acknowledge the co-operation of Mr. T. F. W. Harris, who handled much of the analytical work, and contributed valuable criticism of the results.

Summary

A survey of pollution in the Bushmans river, and a tributary, the Little Bushmans river in the vicinity of Estcourt, Natal, is described. The pollution arose mainly from wastes discharged from a board-mill, a milk-processing factory, and a sewage-disposal, irrigation farm. The effects of these effluents on the chemistry of the river waters, and on the biological communities in them is described.

The communities at polluted stations have been classified in relation to the degree of pollution, and the equivalence of the classification with the systems described by other workers has been indicated. Differences observed between communities in normal and polluted stretches of the rivers are suggested as indices of pollution.

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Thécamoebien des terres de Belgique II

par

Didier Chardez

I

De tous les sols étudiés jusqu'à présent, ce sont les sols de forêts qui se montrent les plus riches en Thécamoebiens à un tel point que l'on peut considérer le terreau des forêts comme un biotope particulier.

Dans un sens très général au point de vue Thécamoebologique on peut concevoir le profil d'un sol de forêt formé de quatre zones:

1. *Zone de surface:* Plus ou moins épaisse formée de gros débris la plus part encore identifiables, feuilles mortes, aiguilles de sapin, brindilles écorces . . . etc . . .
2 *Zone humifère:* Débris précédents réduits fragmentés et en fermentation.
3 *Zone mixte:* Mélange de 2 et 4.
4 *Zone minerale:* C'est dans les Zones 2 et 3 que vit la masse des Thécamoebiens la zone 3 renferment en plus la faune résiduelle de 2.

Cette Zone humifère riche en Thécamoebiens qui se trouve sous la couche de surface peut se représenter comme une immense couche plus ou moins épaisse extrèmement poreuse formée d'une infinité de microcavernes constituées d'éléments les plus variés; dans cette couche les variations de température sont très atténuées par la protection qu'offre la couche supérieure c'est l'endroit des opérations chimiques en cours, fermentations, minéralisations, c'est dans cette couche qu'arrivent les composés chimiques les plus divers, résultant du lessivage, des dilutions et de la fragmentation de la couche de surface.

La composition chimique de cette couche bien connue des pédologues dépend des apports organiques fournis par la végétation, elle est du reste fort complexe, comprenant entre autres des hydrates de carbonne, des amidons, des sucres, des acides gras, des tanins, des protéines, des graisses des celluloses des chitines, et des matières minérales.

L'examen d'une pincée de cette couche au stéréomicroscope montre qu'elle est formée d'une infinité de débris dans un stade plus ou moins avancé de décomposition le tout enrobé d'un film d'eau. 10 gr. de cette terre contient 6 gr. d'eau, met 48 h. à se déssécher complètement à une température de 16° en laboratoire, et peut absorber 8,5 cm^2 d'eau. Son humidité latente en temps normal suffit à énormément de microorganismes pour vivre et se développer; si on immerge ce terreau dans de l'eau distillée on y verra nager après 10 à 15 minutes des infusoires, des ciliés, des flagellés et même des rotifères. Il ne s'agit pas ici de mise en culture qui, comme le fait remarquer R. Thomas, risque de fausser l'idée qu'on se fait des faunules des sols.

Cette couche étudiée ici peut être considêrée comme un milieu subaérien très riche en matières organiques et bien tempéré; c'est un biotope particulier, un substrat lacunaire ou poreux, capable de s'imprégner très fortement et dont le pouvoir de rétention est très grand.

L'examen des listes habituelles fournies par ces sols, présentent souvent un facies bien particulié, mais souvent fait penser aux formes habituelles aux mousses; il faudra bien des études si l'on veut comprendre ou est l'influence et ce qui détermine exactement les répartitions.

II

Les mousses épigées ne sont pas rares sur les sols de forêt. Un des caractères primordiaux des muscinées en général est leur grand pouvoir de rétention de l'eau météorique d'une part et de l'absorbsion de l'eau du sol par capilarité d'autre part. Le grand besoin d'humidité des Thécamoebiens motiverait donc leur développement dans les terres sousjacantes aux mousses. Il est bien souvent très difficile voir impossible de séparer les faunes muscicoles et terricoles dans pareil cas, car ici il y a danger de contamination directe. Il n'est pas impossible que les deux faunes soient intimement liées, car si l'on considère une motte, un coussinet ou un tapis de mousses épigées avec tout son support de terre on verra que l'ensemble forme un biotope où les caractères primordiaux, à savoir, l'humidité, l'acidété, l'aération, sont communs. Toutefois on peut malgré tout noter une préférence nette, pour quelques organismes du reste fort peu nombreux.

Les stations étudiées dans ce travail ont été choisies sur des points élevés loin de tout voisinage aquatique, les prélèvements terres exécutés là où il n'y a pas de mousses, à des endroits où le caractère terricol est constant, ceci afin d'éviter tout mélange de faune possible . . .

Quand aux prélèvements „muscicols” et „terricols sousjacents” ils ont été exécutés de la façon suivante: les mousses ont été coupées aux ciseaux et la terre prélevée directement sous les racines.

III

Prélèvements

Terre

A. OREYE (Hesbaye) Butte boisée, nombreux taillis, grands chènes, hêtres et bouleaux, sous sol limoneux: sous la couche de surface à 4 cm. de prof. pH 5.
B. SPA (Ardennes) en forêt de sapins, sous la couche de surface presqu'uniquement formée d'aiguilles de sapins à 4 cm. de prof. pH 4.
C. PECROT (Brabant) en forêt de chènes sous la couche de surface à 4 cm. de prof. pH 4^5.
D. OTRANGE (Hesbaye) butte boisée, chènes, hêtres sous-sol limoneux, sous la couche de surface 5 cm. de prof. pH 5^5.

Mousses

1. Forêt de feuillus à Bockerijk (Genk) au pied d'un arbre pH 5.
1* Terre sous jacente pH 5.
2 Forêt de pins à Zolder sur sol pH 5.
2* terre sous jacente pH 4^5.
3 Bois Goulet à Jalhay sur sol pH 5.
3* Terre sous jacente pH 4^5.

Liste et repartition des éspèces

Dans la liste suivante les prélèvements désignés par des lettres, sont purement terricols, ceux désignés par des chiffres de 1 a 3 sont des „terres sous mousses” tandis que ceux de 1* a 3* sont purement muscicols.
Les chiffres gras indiquent les influances probables.

TRINEMA lineare Penard A-B-C-D- **1-1*—2-2*—3-3***
„ *penardi* Thomas-Chardez A
„ *enchelys* (Ehrbg) Leidy A-B- **1-1***
„ „ fr. *biconvexa* Auerintzew B
„ *complanatum* Penard A-B-C-D- **2-2***—3
„ „ var. *globulosa* Chardez A-D- **1-1*-2-2***
CORYTHION dubium Taranek **3-3***—2*
„ *pulchellum* Penard 2*

ASSULINA muscorum Greeff A-D-1*2*-3*

„ *seminulum* Ehrbg 3*

EUGLYPHA compressa Carter 1*

„ *strigosa* (Ehrbg) Leidy B-3-2*

„ „ fa *glabra* Wailes A

„ *rotunda* Wailes A-C-D-1-*-2*-**3-3***

„ *loevis* Perty D-**1-1***-2*

„ *ciliata* (Ehrbg) Perty 3*

TRACHELEUGLYPHA acolla Bonet-Thomas A-C-D-1

„ „ fa. *stenostoma* fa. nov. A

DIFFLUGIELLA oviformis va *fusca* Penard A-B

NEBELA tincta (Leidy) Awerintz. **3-3***

HELEOPERA sylvatica Penard A

„ *petricola* var. *major* Cash. A

CENTROPYXIS aerophila Defl. B-C- **3-3***

„ „ var *sphagnicola* Defl. A-B-2-2*

„ „ var *globulosa* B. Th. C

„ *sylvatica* Defl.) Thomas D

„ *ecornis* Leidy. A

„ *plagiostoma* Bon. Thom. C

„ *minuta* Deflandu A

CYCLOPYXIS arcelloïdes Penard A

TRIGONOPYXIS arcula (Leidy) Penard A-B-C-D-1-**2-2***-2

GEOPYXELLA sylvicola Bonnet-Thomas 3

PLAGIOPYXIS declivis Thomas A-B-D-1-2-3

„ „ var. *oblonga* Bon. Th. 3

„ *callida* Penard B-C-D-**1-1***-**2-2***

„ „ var. *grandis* Thom. A-B-D- 1-2-**3-3***

PHRYGANELLA acropodia Hert. et Less. A-B-C-D- 1-**2-2***-**3-3***

„ „ var. *penardi* Decloitre D- 1-**2-2***

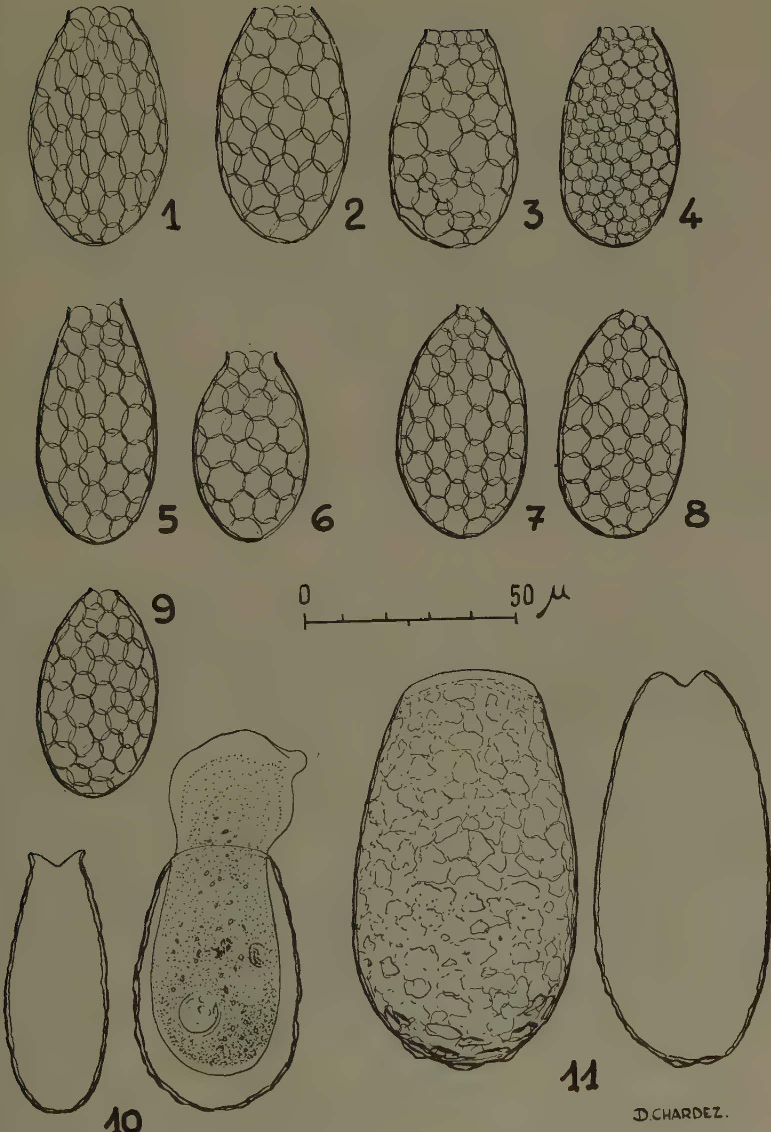
Remarques sur quelques especes

HELEOPERA sylvatica Penard Fig. 10

Assez fréquent dans ce prélevement j'ai pus l'observer vivant et en activité... l'émission pseudopodique est souvent large et lamelliforme avec un unique ou deux pseudopodes au plus, le plasma est claire et souvent sans épipodes. L. Bonnet dans une récente étude (2) a également noté l'absence d'épipodes chez *PLAGIOPYXIS minuta* Bonnet. Ce trais serait-il particulier aux organismes vivants dans les erres?

Le pseudostome est assez évasé lorsqu'il est vu de profil.

Le noyau sphérique et volumineux a plusieurs caryosomes.


1
2
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6
7
8
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50 μ
10
11
D.CHARDEZ.

HELEOPERA pétricola var. *major* CASH Fig. II

Les organismes observés étaient assez peu comprimés.

TRACHELEUGLYPHA acolla BONNET THOMAS Fig. 1-2-3-4-5-6

Parmi les très nombreux individus observés j'ai pu constater des variations assez interéssantes surtout en ce qui concerne la disposition des écailles du revètement qui se présente de plusieurs types:

1. écailles circulaires régulièrement grandes. Fig. 2
2. écailles circulaires régulièrement petites. Fig. 4
3. écailles circulaires irrégulières (grandes + petites) Fig. 3
4. écailles ovalaires Fig. 1

Dans le cas du revètement 4 les écailles de la région du pseudostome sont toujours circulaires ainsi que souvent celles de la région postérieure ou l'arrangement n'est plus si régulier. Il est à remarquer que la régularité de forme et de disposition des écailles, conditionne l'harmonie des formes de la coquille.

TRACHELEUGLYPHA acolla fa. *sténostoma* fa. nov. Fig. 7-8-9.

Se différencie du type par un pseudostome extrêmement étroit représentant environ le $^1/_5{}^\circ$ du diamètre de la thèque, le plus souvent il n'y a absolument pas d'indication de col autour du pseudostome.

Dimensions observées: H 42 a 53μ diam. 21 a 26μ Diam. pseudost. 4 a 7μ

TRINEMA pénardi THOMAS-CHARDEZ

Les organismes observés dans ce prélèvement sont généralement grands et robustes, ils atteignent 88μ ce qui est nettement superieur à ce que nous avions observé avec R. THOMAS dans des mousses des Ardennes, où les maxima étaient de 55 μ.

Les écailles sont circulaires irrégulières de tailles généralement grandes et bien visibles sur le corps de la thèque.

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Hydrobiologische Untersuchungen in einigen abwasserbelasteten niederrheinischen Gewässern

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1. Einleitung

Abwasser jeder Art führen zu erheblichen Gleichgewichtsstörungen innerhalb geschlossener, unabhängiger Biocoenosen eutropher Gewässer. Nach THIENEMANN (1955) bildet die Lebewelt des Wassers einen guten Indikator für den Zustand eines Gewässers. Es soll untersucht werden, in welchem Maße und in welcher Weise sich die Abwasserzufuhr in einigen niederrheinischen Gewässern vornehmlich auf die Flora ausgewirkt hat, und wie schnell sich ein solches Gewässer nach Inbetriebnahme von Klärwerken wieder erholt. In den Jahren 1938 bis 1954 erreichte die Verschmutzung ihren Höhepunkt, dann erst klang sie infolge des Baus von Klärwerken wieder langsam ab. Dadurch ergaben sich Möglichkeiten zu Vergleichsuntersuchungen, wobei teilweise auf Arbeiten aus den Jahren 1912 bis 1938 zurückgegriffen wurde.

Speziellere Untersuchungen wurden an den Netteseen, den Niepkuhlen und an der Niers durchgeführt.

2. Lebensvoraussetzungen in einem eutrophen Gewässer

Der nährstoffreiche Binnensee ist charakterisiert durch seinen Reichtum an Nährstoffen, insbesondere Stickstoff und Phosphorsäure. Er ist in jedem Falle ein hochproduktiver Typus. Das Plankton ist reichlich entwickelt, die Uferbank flach und die Pflanzenwelt infolgedessen optimal ausgebildet. Die Tiefe enthält in großer Menge organische Substanz, und der Faulschlamm ist infolgedessen reich an Nährstoffen. Der jährliche Nahrungskreislauf garantiert ihren

ständigen Nachschub. Eine Verschlechterung der Lebensvoraussetzungen kann nur dann eintreten, wenn die notwendigen Lebensbedingungen mehr oder weniger gleichmäßig ins Minimum geraten, oder wenn ein Einzelfaktor durch irgendwelche Ursachen extrem zur Entfaltung gelangt. Das geschieht durch die Zufuhr von Abwasserstoffen, die entweder eine ausgesprochene Giftwirkung ausüben oder zu einer abnormalen Nährstoffanreicherung führen. In jedem Fall wird dann das hydrochemische Gleichgewicht des Gewässers stark gestört.

Die Hydrophyten (submerse, natante und amphibische Formen) sind je nach ihrer Lebensweise unterschiedlich gebaut. Ihre Hydromorphie befähigt sie, unmittelbar Kohlensäure, Sauerstoff und Nährsalze aufzunehmen. Pro Liter Wasser sind im Falle der Sättigung bei 20° C nur 6 ccm Sauerstoff, jedoch immerhin 0,3 ccm Kohlensäure vorhanden. Den Wasserorganismen steht also wesentlich weniger Sauerstoff (1 l Luft enthält 210 ccm O), aber ebensoviel Kohlensäure wie in der Luft zur Verfügung. Das gilt insbesondere fur nur schwach strömende und weitgehend unbewegte Gewässer.

Die submersen Pflanzen besitzen sehr dünne, nur von einer zarten Kutikula überspannte Epidermisaußenwände. Sie stellen dem Gas-, Wasser- und Salzeintritt kaum Schwierigkeiten entgegen, sofern sie nicht durch irgendwelche im Wasser enthaltenen Verbindungen stark inkrustiert sind. Die Langsamkeit der Gasdiffusion im Wasser und seine relative Salzarmut wird kompensiert durch eine erhebliche Oberflächenvergrößerung der Blätter. Mangel an Transpiration (Spaltöffnungen fehlen meist), schwache Entwicklung der Wasserleitungsbahnen und infolgedessen Fehlen eines lebhaften Wassertransportes kennzeichnen ihre besondere Lebensweise. Die Interzellularen sind in allen Organen mächtig entwickelt. Sie dienen gewöhnlich als Luftspeicher, die den Pflanzen im Wasser den Auftrieb verleihen und ermöglichen eine rege Gasdiffusion im Innern des Körpers. Sie begünstigen also die Atmung. Notwendig für das Pflanzenleben im Wasser ist außerdem eine genügende Belichtung. Deshalb ist das Wachstum meist auch nur an ganz bestimmte Seezonen gebunden. Die Durchsichtigkeit des Wassers ist also dafür ausschlaggebend. Vorhandensein von pflanzlichen Organismen ist stets Voraussetzung für ein tierisches Leben im Gewässer. Die Pflanzen vermögen aus anorganischen Stoffen organische aufzubauen, die für das Tierleben eine unbedingte Voraussetzung darstellen. Sie sind also die Produzenten und die Tiere sind die Konsumenten, die aber nicht alle gelieferten Stoffe aufbrauchen können. Hier greifen die Bakterien ein, die die organischen Stoffe in anorganische abbauen können und sie somit wieder für die Pflanze nutzbar machen. Die Bakterien benötigen aber ebenso wie die Tiere

Sauerstoff zum Leben, der bei einem unbeeinflussten Gewässer stets in nötiger Menge zur Verfügung steht. Aufgezehrt wird er erst durch abnormale Prozesse der Fäulnis, bei der es zu einem Sauerstoffschwund kommt.

3) Art und Wirkung der Beeinträchtigungen

Den weitaus größten Teil der anfallenden Abwasser lieferten Gerbereien, Textil-, Papier- und Zuckerfabriken. Hier sind es besonders Kalk- und Chromverbindungen, Schwefelnatrium und organische Gerbbrühen: N-freie, schwach saure Substanzen z.B. Tannine, Neradole (Phenolsulfosäuren und Formaldehyd), sowie die Schmutz- und Begleitstoffe der Häute, deren Haare sich in Kalk und Schwefelnatrium lösen. Aus den Textilbetrieben fallen Laugen, Säuren und Farbstoffe an sowie künstliche Waschmittel (Saponine, Sulfite, Sulfide und Dextrin). Die stadtischen und hauslichen Abwasser fallen kaum ins Gewicht. Über die chemische Zusammensetzung mögen die folgenden Tabellen Aufschluß geben, die einer Arbeit von Jung (1952) entnommen sind:

Tabelle I

Zusammensetzung der Textilabwasser. (Bis 1955 ungeklärt in die Netteseen).

Art des Betriebes.	Färberei	Färberei	Bleicherei Färberei
Verarbeitung	Wolle	Baumwolle	Baumwolle
Äußeres	Rötlich, trübe	Dunkelblau undurchsicht. trübe.	Braun, undurchs. trübe.
pH	6,8	9,1	11,5
Abdampfrückstand (filt.)	2068 mg/l.	1240 mg/l.	2327 mg/l.
davon: organisch	460 „	437 „	838 „
mineralisch	1608 „	803 „	1489 „
$KMnO_4$-Verbrauch	312 „	733 „	534 „
Biochem. Sauerstoff-Bedarf	93 „	188 „	191 „
Chloride (Cl)	114 „	118 „	255 „
Organ. Stickstoff	4 „	16 „	22 „
NH_3	6 „	Spur	Spur.

TABELLE II

Zusammensetzung von Gerbereiabwassern. (Bis 1955 *ungeklärt in die Nette).*

	Gerbereiabwasser	Städt. Abwasser u. Gerberei.
Äußeres	Braun, undurchsichtig, trübe.	Braun, undurchsichtig, trübe.
pH	12,3	8,7
Abdampfrückstand (filtiert)	5320 mg/l.	3437 mg/l.
davon: organisch	1265 mg/l.	1057 mg/l.
mineralisch	4055 „	2380 „
$KMnO_4$-Verbrauch	2498 „	1959 „
Biochem. Sauerstoff-bedarf	622 „	740 „
Chloride (Cl)	732 „	910 „
Organ. Stickstoff	51 „	60 „
NH_3	—	30 „

Die Folgen der Verschmutzung waren: Rückgang des Fischreichtums infolge Sauerstoffmangel, Fehlen von Fischnährtieren und von für die Fischzucht produktiven Pflanzen (hauptsächlich submerse Formen). Andere Pflanzen und besonders Pilze entwickelten sich dagegen massenhaft, die Verlandungserscheinungen nahmen zu. Durch den zu hohen Salzgehalt konnten sich zu bestimmten Zeiten, aber nicht immer, gewisse Planktonten, z.B. Diatomeen, explosionsartig entwickeln, ihre Assimilationstätigkeit wurde gesteigert, und dadurch entzogen sie dem Wasser in erheblichem Maße Kohlensäure. Es kam zu einer langsamen Alkalisierung des Wassers, die sich wiederum schädlich auf die Fischzucht und die Vitalität vieler Wasserpflanzen auswirkte. Es kam zu Fäulnisvorgängen, die einen erheblichen Sauerstoffschwund bedingten, wovon dann ihrerseits die Tierwelt betroffen wurde. Die Schadwirkungen waren also außerordentlich wechselseitig. Die Gewässer konnten einfach durch ihre biologischen Selbstreinigungskräfte allein nicht alle zugeführten Abwasserstoffe verarbeiten. Eine Mineralisierung des organischen Schlamms durch Bakterien unterblieb; mächtige Faulschlammbänke entstanden, wuchsen stets an, und intermediäre Produkte wie Schwefelwasserstoff und Amoniak konnten sich entwickeln und ihre schädliche Wirkung auf die Gesamt-Lebewelt ausüben. Jedes Gewässer verlandet naturgemäß im Laufe von Jahrhunderten. Wenn sich aber innerhalb von wenigen Jahrzehnten der Röhrichtgürtel erheblich verbreitert und das Gewässer an Tiefe um ca. 50 cm ab-

nimmt, so sind diese Vorgänge schon nicht mehr natürlich, sondern stets eine Folge des schlechten Wasserzustandes.

Mittlerweile haben sich die Verhältnisse an den Netteseen ebenso wie an der Niers durch die Inbetriebnahme von Klärwerken während der letzten 5—10 Jahre stark gebessert. Die Auswirkungen ergeben sich aus nachfolgenden Tabellen. Als Beispiel für ein sterbendes Gewässer sei die Waldwinkelkuhle im Verband der Niepkuhlen bei Krefeld angeführt, in der sowohl Abwasser als auch schlechte Durchströmungsverhältnisse bis heute wirksam sind. Hier werden die Lebensbedingungen von Jahr zu Jahr schlechter und die Verlandung schreitet stetig vor.

4) Vergleichsmessungen und Untersuchungen

In der folgenden Tabelle sollen zunächst die Reinigungswirkungen der Klärwerke wiedergegeben werden.

Tabelle III

Reinigungswirkung nach dem Niersverfahren (nach Jung (1952)), *seit* 5—6 *Jahren für die Netteseen wirksam.*

	Textilabwasser		Gerbereiabwasser	
	unbehandelt	behandelt	unbehandelt	behandelt
Äußeres	Dunkelgrün, undurchsicht. trübe	Gelblich fast klar.	Braun, undurchsichtig, trübe.	Farblos, klar.
Durchsichtigkeit	2 cm	16 cm	1 cm	30 cm
pH	8,9	8,7	6,8	7,1
Abdampfrückstand (filtriert)	1585 mg/l.	1295 mg/l.	1250 mg/l.	881 mg/l.
davon: organisch	864 „	524 „	746 „	415 „
mineral.	721 „	771 „	504 „	466 „
$KMnO_4$-Verbrauch	604 „	295 „	1390 „	405 „
Abnahme		51%		71%
Biochemischer Sauerstoff-Bedarf	281 mg/l.	161 mg/l.	272 mg/l.	171 mg/l.
Abnahme		43%		37%
Chloride (Cl)	267 „	260 mg/l.	—	175 mg/l.
Organ. Stickstoff	14 „	11 „	18 „	22 „
Amoniak	4 „	4 „	26 „	22 „

TABELLE IV

Vorhandene Wasser- und seltenere Sumpfpflanzen 1920 (*vor der Verschmutzung*), 1952/54 (*Höchststand der Verschmutzung*) *und* 1958/59 (*abnehmende Verschmutzung durch Inbetriebnahme der Klärwerke*) *in den Netteseen. ss = stark sauer, s = wechselnd schwach/stark sauer, ns = überwiegend sauer, n = überwiegend neutral, a = alkalisch.*

Art	1920 n.HÖPPNER	1952/54	1958/59	Verteilung der Ar nach den pH-Ver nissen (n. IVERSE
Equisetum telmateja	zerstreut	fehlend	fehlend	
Sparganium simplex	„	selten	selten	
Sparganium erectum	Häufig	„	„	
Sparganium minimum	zerstreut	fehlend	fehlend	
Potamogeton fluitans	„	„	selten	
Potamogeton natans	häufig	zerstreut	häufig	a, n, ns, s.
Potamogeton gramineus	zerstreut	selten	selten	a, n, ns.
Potamogeton lucens	„	fehlend	fehlend	a.
Potamogeton crispus	zerstreut	häufig	abnehmend	a, n.
Potamogeton perfoliatus	„	fehlend	selten	a, n, ns.
Potamogeton praelongus	selten	„	fehlend	a.
Potamogeton pectinatus	zerstreut	„	„	a. Charakt. für a Gewässer.
Potamogeton obtusifolius	„	„	„	a.
Potamogeton pusillus	selten	„	„	a, n, ns.
Triglochin palustre	„	„	„	
Alisma plantago-aquatica	häufig	zerstreut	häufig	
Sagittaria sagittifolia	zerstreut	selten	zerstreut	
Butomus umbellatus	„	fehlend	selten	
Stratiotes aloides	selten	fehlt	fehlt	a.
Hydrocharis morsus-ranae	häufig	sehr selten	zerstreut	a, n, ns.
Elodea canadensis	zerstreut	selten	zerstreut	a, n.
Calla palustris	Häufig	selten	zerstreut	
Acorus calamus	„	zerstreut	häufig	
Spirodela polyrrhiza	„	fehlt	zerstreut	a.
Lemna trisulca	„	häufig	häufig	a, n.
Lemna minor	„	„	„	a, n, ns, s, ss.
Polygonum amphibium	„	selten	zerstreut	a, n, ns, s, ss.
Ceratophyllum demersum	häufig	sehr häufig	abnehmend	a. Charakt. für a lische Gewäss
Ceratophyllum submersum	selten	fehlt	fehlt	
Nymphaea alba	häufig	beeinträchtigt	häufig	a, n, ns, s, ss.
Nuphar luteum	„	„	„	a, n, ns, s, ss.
Ranunculus fluitans	zerstreut	fehlt	selten	
Ranunculus aquatilis	häufig	„	„	a, n, ns.
Ranunculus divaricatus	zerstreut	selten	selten	
Ranunculus sceleratus	„	häufig	zerstreut	
Ranunculus lingua	„	fehlt	selten	
Nasturtium amphibium	häufig	fehlt	selten	
Callitriche stagnalis	„	selten	selten	
Callitriche verna	„	„	„	
Myriophyllum verticillatum	zerstreut	fehlt	fehlt	a.
Myriophyllum spicatum	selten	„	„	a, n.
Hippuris vulgaris	„	„	„	a, ns.

Man erkennt daraus die erhebliche Artenzahl vor Beginn der großen Abwasserverschmutzung. Nur wenige Arten sind in den letzten Jahren wieder zur Entwicklung gekommen, ihre erneute Ausbreitung scheint noch etwas gehemmt zu sein. Eine weitere Gruppe (z.B. *Ceratophyllum demersum* und *Potamogeton crispus*) scheint durch die Abwasserwirkung gefördert worden zu sein; ihre augenblickliche Ausbreitungstendenz ist jedoch rückläufig, da die alkalischen Werte abgenommen haben. Lediglich die *Lemna*-Arten scheinen gegen Änderungen im Wasserchemismus resistent zu sein. Die Gesamtverbreitung der Wasserpflanzen entspricht nicht ganz den von IVERSEN (1929) für die dänischen Gewässer gefundenen Ergebnissen.

Auch im Plankton lassen sich gewisse Veränderungen infolge der Abwasserzufuhr feststellen. Eine explosionsartige Massenentfaltung gewisser Planktonten, wie sie andernorts infolge Abwasserzufuhr festzustellen war, ließ ich im Nettegebiet mit Ausnahme von Diatomeen kaum beobachten. In den Jahren stärkerer Verschmutzung war die jährliche Wasserblüte merkwürdigerweise weit geringer als etwa in den Jahren 1933/34 und 1958/59 (Vergl. hierzu GEIST, 1934 und HILD, 1960). Speziellere Untersuchungen sind noch in Gang. Das auch schon von THIENEMANN (1925) beobachtete Auftreten von *Carinogammarus roeseli* mit seinen beiden Infusorien *Spirochona gemmipara* und *Dendrocometes paradoxus* als Indikator für den Reinheitsgrad des Wassers ist besonders charakteristisch für die veränderten Verhältnisse während der letzten Jahre. (Vergl. HILD, 1960).

Untersuchungen über die Verbreitung von Arthropoden und Mollusken werden z. Zt. noch vom Zoologischen Institut der Universität Köln durchgeführt. Ob hier allerdings Vergleiche möglich sein werden, erscheint fraglich, da entsprechende Untersuchungen in den dreißiger Jahren kaum durchgeführt wurden.

Die Ornis hat sich durch die Abwassereinwirkung nur wenig verändert, wie aus entsprechenden Artenlisten hervorgeht.

Ähnliche Verhältnisse hinsichtlich der Vegetation ließen sich an der Niers und an der Waldwinkelkuhle beobachten. Dabei ist an der Niers die augenblickliche Tendenz wieder etwas fortschreitend, da auch hier eine Besserung der Wasserverhältnisse eingetreten ist, während an der Waldwinkelkuhle die Tendenz eine rückläufige ist, da hier in den letzten Jahren keine wesentliche Änderung der Wasserverhältnisse festzustellen war.

Die Verschmutzung der Niers war so erheblich, daß sie auch heute teilweise noch unter den Folgen zu leiden hat. Dennoch lassen die mittlerweile wieder vorhandenen Pflanzen eine erneute Besiedlung erwarten, was immerhin bemerkenswert ist, wenn man bedenkt, daß in den Jahren 1940-1950 keinerlei Wasserpflanzen mehr vorhanden waren.

Tabelle V

Wasserpflanzen der Niers bei Beginn (1931) *und nach* (1953-59) *der Hauptverschmutzung. Die Angaben für* 1931 *sind unveröffentlichten Notizen von* Steussloff *entnommen.*

Art	1931	1953/59	pH-Ansprüche n. n. Iversen (1929)
Equisetum telmateja	selten	selten	
Sparganium erectum	zerstreut	fehlt	
Sparganium simplex	zerstreut	fehlt	
Potamogeton crispus	selten	zerstreut	a, n.
Potamogeton natans	zerstreut	selten.	a, n, ns, s.
Potamogeton pusillus	zerstreut	fehlt	a, n, ns.
Potamogeton pectinatus	selten	„	a.
Sagittaria sagittifolia	selten	„	
Stratiotes aloides	selten	„	a.
Hydrocharis morsus-ranae	selten	„	a, n, ns.
Elodea canadensis	zerstreut	zerstreut	a, n.
Acorus calamus	häufig	zerstreut	
Spirodela polyrrhiza	zerstreut	fehlt	a.
Lemna minor	häufig	zerstreut	a, n, ns, s, ss.
Lemna trisulca	zerstreut	fehlt	a, n.
Polygonum amphibium	„	„	a, n, ns, s, ss.
Ceratophyllum demersum	selten	zerstreut	a.
Nuphar luteum	zerstreut	verminderte Vitalität	a, n, ns, s, ss.
Callitriche stagnalis	häufig	selten	
Myriophyllum verticillatum	selten	fehlt	a.
Riccia fluitans	zerstreut	fehlt	ns, s.

Tabelle VI

Pflanzenbestände in der Waldwinkelkuhle vor der Verschmutzung (1926 *n.* Höppner) *und während der Hauptverschmutzung* 1956/57. (*Vergl. dazu auch Tab. XI*)

Art	1926	1956/57	pH-Ansprüche n. Iversen (1929)
Potamogeton natans	reichlich	selten	a, n, ns, s.
Potamogeton crispus	„	„	a, n.
Potamogeton alpinus	zerstreut	fehlt	a, n.
Potamogeton obtusifolius	selten	„	a.
Potamogeton lucens	zerstreut	„	a.
Potamogeton pusillus	„	„	a.
Sagittaria sagittifolia	„	„	
Hydrocharis morsus-ranae	reichlich	mäßig	a, n, ns.
Lemna minor	„	reichlich	a, n, ns, s, ss.
Ceratophyllum demersum	„	„ aber rückläufig.	a.
Nuphar luteum	„	kümmernd	a, n, ns, s, ss.
Nymphaea alba	„	„	a, n, ns, s, ss.
Ranunculus circinatus	selten	fehlt.	
Nasturtium amphibium	zerstreut	selten	
Callitriche verna	„	zerstreut.	
Myriophyllum verticillatum	„	sehr selten	a, n, ns.
Menyanthes trifoliata	„	fehlt	

I I TABELL VE

Fischerträge der Krieckenbecker Seen. (Angaben in kg).

Art.	1937	1953	1959
Abramis brama (Bressen)	keine	255	keine
Tinca tinca (Schlei)	genauen	190	genauen
Esox lucius (Hecht)	Fang-	150	Fang-
Anguilla anguilla (Aal)	ergebnisse	55	ergebnisse
Perca fluviatilis (Barsch)	bekannt.	35	bekannt.
Cyprinus caprio (Karpfen)		10	
Insgesamt	2500 kg. ca.	695 kg.	1230 kg. ca.

TABELLE VIII

Durchschnittliche Mächtigkeit des unzersetzten Schlamms in den Krieckenbecker Seen.

Pflanzengesellschaft	1930	1953/54	1958/59
Röhrichtzone	25 cm	65 cm	abnehmend
Seerosenzone	30 cm	75 cm	abnehmend
Laichkrautzone	15 cm	60 cm	abnehmend
Unbewachsene Zone	10 cm	75 cm	abnehmend
Durchschnittliche größte Seetiefe ohne mineralisierte Schlammschicht	300-350 cm	250-300 cm	250-300 cm abnehmend.

TABELLE IX

Schlammuntersuchung. (Mittelwerte von je 10 *Meßstellen)*

	1930	1953/54	1958/59.
Schlamm % Wasser % Trockensubstanz	keine Werte bekannt.	89,85% 10,15%	92,15% 7,85%
Trockensubstanz % mineralisch % organisch	der mineralische Gehalt überwog um 2/3 den org.	54 % 46 %	63 % 37 %
Pflanzenreste	unbekannt	meist erheblich	gering
H_2S-Gehalt (Bleipapierprobe) (Juni)	keine Hinweise.	mäßig.	geringe Reaktion an 10% der Entnahmestellen.
O-Gehalt (sofort) (Juni)	gut	gering	mäßig.
Durchsichtigkeit des Seewassers. (Juni)	nicht bekannt	5-10 cm	25 cm.

TABELLE X

pH-Wert-Schwankungen während eines Jahres in den Netteseen. (Durchschnittswerte aus je 40 *Messungen)*

Gesellschaft	1930	1953/54	1958/59.
Röhrichtzone	keine Werte bekannt.	Zwischen 7,8 im Okt. und 5,2 Jan./März.	zwischen 5,7 im Okt. und 5,0 im Jan./März.
Wasserpflanzenges.	keine Werte bekannt.	zwischen 7,2 im Okt. und 5,0 Jan./März.	zwischen 5,8 im Okt. und 4,6 im Jan./März.

TABELLE XI

Hydrochemische Verhältnisse und Schlammuntersuchungen an der Waldwinkelkuhle bei Krefeld. (Werte in mg/l.)

	pH(Mai)	freier O	CO_2	H_2S	NH_3	CaO	Org. Schlamm %	Mineral. Schl. %
1933 n. BAIER	7,7-8,0	9,1	17,6	—	—	192,4	35,10	64,90
1957 eig. Mess.	5,6-5,8	5,5	20.3	Spuren		135,4	43,70	56,30

5) ZUSAMMENFASSUNG

Untersucht wurden die Einwirkungen der verschiedenen Abwasser auf die Lebewelt, insbesondere auf die Vegetation einiger niederrheinischer Gewässer des eutrophen Typus. Pflanzen und Tiere sind an den Nährstoffreichtum der Gewässer gebunden und aufeinanderangewiesen. Die hydromorphe Struktur der submersen Formen ist dem Medium angepasst. Das Gleichgewicht in allen Lebensvorgängen ist so lange garantiert, wie keine Abwasserzufuhr erfolgt. Die Untersuchungen ergaben im einzelnen:

a) Hauptverschmutzer der erwähnten Gewässer sind Gerbereien und Textilfabriken. Ihre Abwasser bedingen u.a. eine Zunahme des Alkalitätsgrades und eine Abnahme des O-Gehaltes. Städtische und häusliche Abwasser fallen kaum ins Gewicht.

b) Die hervorstehendsten Folgen davon waren: Rückgang des Fisch-, Wasserpflanzen- und Planktonreichtums, Zunahme nur bestimmter Arten (*Ceratophyllum demersum* und *Potamogeton crispus*), schnellere Verlandung, CO_2- und O-Armut in den meisten Fällen, teilweise Entstehung von H_2S und mächtigen Faulschlammbänken, die sich infolge der O-Armut nicht zersetzen können. Nur die Ornis scheint unbeeinflusst gewesen zu sein.

c) Durch die Inbetriebnahme von Klärwerken ist an den Netteseen sowie an der Niers eine offensichtliche Besserung der Verhältnisse eingetreten. Das lässt sich an der Änderung der gesamten hydrochemischen Verhältnisse und an der Zunahme bestimmter Wasserpflanzen und des Fischgehaltes erkennen. Die Schlammbänke sind wieder besser mineralisiert, ihr organischer Gehalt nimmt ab, die Verlandungsvorgänge haben sich verlangsamt.

d) Die Wirkung fehlender Abwasser ist an der Niers n o c h weniger auffallend als in den Netteseen. Die Waldwinkelkuhle dagegen ist ein sterbendes Gewässer.

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Structure de la thèque du genre Corythion Taranek

par

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Taranek, en 1882, crée le genre *Corythion*. Il écrit au sujet de la thèque: „La structure consiste en très petites plaques siliceuses ovales (souvent rondes à la bouche) très irrégulièrement distribuées noyées dans la substance chitinoïde fondamentale".

Il ne donne aucun renseignement sur la superposition possible des plaques. Il semble, d'après le texte qu'il y a juxtaposition.

Penard, en 1902, écrit: „Cette enveloppe est composée de petites plaques siliceuses, allongées, qui plutôt que des ovales vraies, représentent des rectangles fortement arrondis, serrés les uns contre les autres (nous soulignons) et disposés sans ordre en séries le plus souvent longitudinales, parfois ondulées."

Pour cet auteur, les écailles sont donc juxtaposées, c'est très net d'après le texte.

Cash-Hopkinson-Wailes écrivent en 1915: „test petit, hyalin composé de petites écailles ovales siliceuses, non imbriquées (nous soulignons)". Pour ces auteurs aussi, la juxtaposition des plaques est certaine.

A l'époque, c'est certainement ce que les auteurs voyaient avec l'optique des microscopes qu'ils avaient. Mais malheureusement, cela est faux.

Avec un objectif ordinaire 85 et même 100 immersion, c'est bien ce que l'on voit. Par contre avec un objectif 85 contraste de phase, on aperçoit un aspect tout différent.

D'abord, les écailles, comme le dit Penard, sont sans grand ordre; cependant, elles présentent deux séries perpendiculaires obliques à l'axe générale de la thèque, séries peu visibles il est vrai, mais non longitudinales comme le voyait Penard.

De plus, les écailles se recouvrent parfaitement. Et en contraste

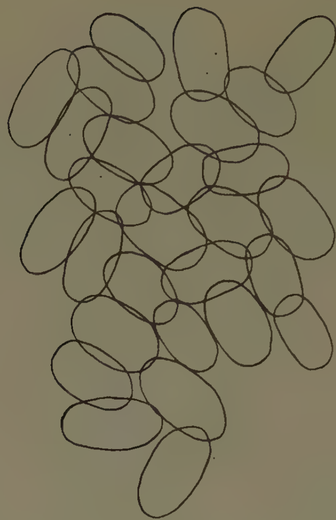

fig. 1

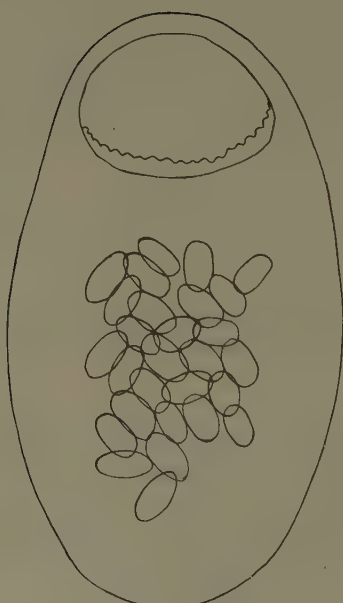

fig. 2

de phase, cela est parfaitement visible. Figure 1. Les recouvrements avant et arrière des écailles sont plus grands que les recouvrements latéraux et plus clairs. De plus, le pseudostome présente un bord dentelé en dents de scie, recourbé vers l'intérieur; ces dents sont extrêmement fines et invisibles avec un objectif ordinaire. Nous en avons compté 5 pour 6,5 μ. Figure 2.

Entre le bord antérieur du pseudostome et le bord antérieur de la thèque, on distingue, en contraste de phase, une ligne ondulée bien nette. Figure 3.

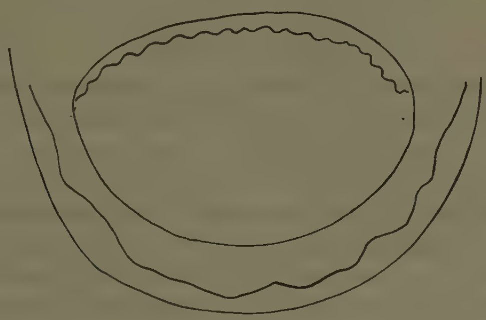

fig. 3

En résumé, les écailles de la thèque de *Corythion* se recouvrent, comme celles d'*Euglypha*, *Trinema*, *Sphenoderia* et autres Thécamoebiens du même groupe. Elles ne sont pas juxtaposées comme on les dessinait jusqu'à maintenant.

The Fifth Conference of Czechoslovakian Hydrobiologists

by

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At the occasion of the fourth conference held in Praha September 30th—October 3rd, 1957 (for the review see *Hydrobiologia* 12: *73—78*, 1958) there was decided that the fifth national conference would be held in Moravia. Later the Hydrobiological Commission elected the town Vranov nad Dyjí (Frain an der Thaya) in South Moravia. Near this town a large artificial reservoir storing 122 million cubic meters of water was constructed in 1930—1934 (fig. 1 and 2, lecture No. 34 and 35). The organization committee of the conference was directed by professor Dr. S. HRABĚ and the members were Dr. M. ZELINKA, Dr. P. MARVAN. Dr. B. LOSOS and Dr. F. KUBÍČEK.

The conference was opened by prof. Dr. S. HRABĚ who welcomed the 80 participants and four guests from abroad: Dr. J. W. G. LUND (England), prof. Dr. K. STARMACH (Poland), miss Mgr. J. SOSNOWSKA (Poland) and mrs. Dr. H. WYSOCKA-BUJALSKA (Poland). The guests participated not only at the hydrobiological conference, but also at the symposium on algology which was held nearly at the same time in Vranov, too.

In the course of the conference 35 lectures were given being in the great majority of cases contributions of an original character. The names of authors, titles and short abstracts are given in the following text.

1. Doc. RNDr. R. ŠRÁMEK-HUŠEK, D.Sc.: „The activity of the Hydrobiological Commission of the Czechoslovak Academy of Science and the present state of the hydrobiological research in Czechoslovakia." The chairman of the Hydrobiological Commission spoke on the establishment, composition, tasks and on the work done through the last two years. He mentioned the present state of the research work carried out at the high schools, in the Academy and in the research and other institutes belonging to the different

ministries. The investigation of the reservoirs is in the foreground of the whole hydrobiological activity, and, on the other hand, the research of fishponds and small water bodies is in retreat.
The applied hydrobiological research in the field of waste water purification needs much of further work.

2. Prom. biol. M. Štěpánek, C.Sc.: „Hydrobioclimatology." The author in his lecture analysed the influence of climatical and meteorological factors upon the water life. Many years long observations and measurements are needed for this purpose. The author believes that he will be able to conclude an eleven years period started in 1954 on the reservoir Sedlice. The results gained up to now have enabled him to formulate some relationships mathematically. Especially the relation between the standing crop of the phytoplankton and meteorological factors has been detected. A lively discussion followed this lecture. Examples taken from marine biology and plant physiology were compared with the results and statements of the author. A comprehensive paper in English is in press in the *Scientific Papers from Institute of Chemical Technology, Prague, Faculty of Technology of Fuel and Water* 4 (2), 1960.

3. RNDr. P. Blažka, C.Sc.: „The changes in chemical composition of the plankton and benthos during the year." The author ascertained that in the weight biomass 1 *Daphnia pulicaria* equals 100.000 cells of *Ankistrodesmus sp.*, 1 *Chironomus plumosus* equals 200 *Daphnia pulicaria*, 1 *Daphnia pulicaria* equals 60 *Bosmina longirostris*, 1 *Daphnia pulicaria* equals 6 *Cyclops sp.* with eggs, 1 *Daphnia pulicaria* equals 3 *Daphnia longispina*. In the dry weight of the zooplankton 78,5% of crude proteins, 7,2% of reserve carbohydrates and 14,3% of lipides were determined, in the same of the benthos there were 65,3% crude proteins, 21% of reserve carbohydrates and 13,6% of lipides. The dry weight of fish contains 84% of crude proteins, 4% of reserve carbohydrates and 12% of lipides.

4. Mrs. prom. chem. L. Procházková: „The methods of determination of different nitrogen forms and their presence in some water bodies." After a description of the methods applied, the author gave some results gained in studying the fishponds at Blatná and the reservoir Slapy. In summer in the surface water of the reservoir Slapy 0,5 till 1,0 p.p.m. N are present. This value is in correspondence with the same found in the fishpond Velký Pálenec. The larger is the water body, the more nitrogen is present, the organic compounds prevailing over the inorganic forms. In the anaerobic zone at the bottom of the reservoir Slapy free hydroxylamine was detected.

5. Miss prom. biol. V. Prokešová: „B.O.D. and the organic matter decomposition in the water of fishponds and reservoirs." The author gave a survey of the problems concerning the B.O.D. determination

and her own results. The experiments comparing the rotating and still-standing flacks showed higher B.O.D. values in the rotating ones.

6. Prom. biol. M. Štěpánek, C. Sc.: "Contribution to the problematics of water-blooms". During a study of emergent insects captured in the traps based on the models of Wohlschlag and Borutzky the author gained the colonies of blue-green alga *Microcystis* which differed morphologically from those observed on the bottom and later in the water-bloom of the reservoir Sedlice. The rising of the colonies to the water surface may be influenced by an impulse of physical factors. The decaying water-bloom caused an irritation of the mucous membranes of human eyes and nose. The author is of the opinion that the decomposition products and intermediary products of the blue-green algae can act, from the hygienic point of view, as pyogenic substances. In conclusion the measures of prevention of the development of water-blooms were recommended.

7. Miss Mgr. J. Sosnowska (Olsztyn, Poland): "On some factors affecting the rise of the spring maximum of phytoplankton in some lakes in the vicinity of Wegorzew (Poland) being of different morphological type". The author ascertained that the spring maxima proceeded at the water temperatures 7° C, approximately. The phytoplankton consisted mainly of diatoms, namely: *Melosira islandica ssp. helvetica*, *M. ambigua*, *M. granulata*, *Cyclotella comta*, *Diatoma elongatum*, *Asterionella formosa* and *Stephanodiscus astraea*.

8. Mrs. RNDr. M. Hrbáčková, C.Sc.: "The question of races in *Daphnia longispina*". The cladocerans originating from different localities were bred in the laboratory conditions and a different relative increment was ascertained. The Berger's concept of the species *Daphnia longispina* is not more acceptable. The presence of a helmet is a feature of *Daphnia hyalina*, whereas at the species *Daphnia longispina* it is absent. The author supported the results of her husband doc. Dr. J. Hrbáček, that the size of the helmet depends on the water turbulency. A lively discussion followed this lecture.

9. Prom. biol. O. Štěrba and RNDr. P. Marvan: "On the biology of saline waters in Ostrava district". The saline underground waters appear on the surface and they became polluted in a high degree. The authors tried to detect the influence of these saline waters on the biological selfpurification and on the processes in sewage and indutrial wastes plants. Bioassays showed that a concentration of 3.000 p.p.m. chlorides did not affect the psychrophilic, mesophilic and coliform bacteria and that this concentration influenced the life of aquatic microflora and microfauna only in a little degree. The cladocerans proved to be less resistant to the salinity than the copepods.

10. RNDr. Valoušek: The protection of the memorable pools in Moravia". In these pools there live either snow or summer forms of

Euphyllopoda. Only in the "Red pond" at Znojmo in the early spring occurs the snow fauna whereas in the summer months different summer fauna is present. The author names this unusual type of small waters as "stagnum biferum" and gives recommendation for its protection. A list of other memorable pools with *Euphyllopoda* which were annihilated during the last 40 years can serve as a warning against the destruction of the remaining rare localities.

11. Doc. RNDr. R. ŠRÁMEK-HUŠEK, D.Sc.: "The XIV. Congress of the International Association of Limnology in Austria 1959". It was a short review of lectures elected from more than 200 and a description of the total arrangement of the congress having 500 participants, approximately.

12. Mrs. RNDr. L. MAŠÍNOVÁ and prom. biol. J. POKORNÝ: "The weight determination of the bacteriomass in the reservoir Sedlice." The authors determined the weight of the standing crop of bacteria and computed the balance for estimating the increase or decrease of the undesirable matter in the reservoir. In summer the rivulet Kletečná (right inflow) brings into the reservoir 7 g and the rivulet Hejlovka (left inflow) 20 g of coliform bacteria per day. The same values for the winter months are 1 and 15 g, respective. The faecal pollution as indicated by the presence of coliform bacteria is liquidated from 35 % in summer, from 87 % in autumn and from 47 % in winter. The stored water has a good selfpurification. In September up to 95 % of the total introduced bacteriomass was liquidated in the reservoir. Great oscillations in the numbers of bacteria were caused by the rains and by the discharge of the campaign starch factory's wastes. This paper will be published in the same journal as indicated at the lecture No. 2.

13. RNDr. J. CHALUPA, C.Sc.: "Some notions derived from the experimental management of the water quality in the reservoir Sedlice." The reservoirs serving for the water supply purpose have to be artificially treated for stopping the eutrophization process as well as for establishing an oligotrophic state. The staff of the Institute of Hygiene is carrying out since 1955 experiments aimed at the artificial management of the water quality in the reservoir Sedlice. Among the algicides best results were obtained in application of the preparation CA 350, being a mixture of copper sulphate and silver nitrate. In summer 1959 an airplane treatment of the reservoir Fryšták in Moravia was made with good success. In the following discussion prom. biol. J. ŠVEC reported on this treatment in details. A paper written in English is in press in the same journal as indicated at the No. 2.

14. Doc. RNDr. V. SLÁDEČEK, C.Sc., RNDr. L. FIALA and prom. biol. A. SLÁDEČKOVÁ: "The influence of peak-load power plant on the

limnological conditions in the reservoir Pastviny". The rhythmical activity of the peak-load power plant causes during the summer stagnation a quick disturbance and a slow stilling of the stratification of some limnological factors, further the appearance of two thermoclines one above another and the formation of an anaerobic stagnant space at the bottom near the dam. The inflow water of the rivulet Divoká Orlice squeezes into the metalimnion, the flowing off water comes from the middle or partly from the upper hypolimnion. The peak-load activity of the power plant does not influence the epilimnion at all. Only few zooplankton species occurring in the critical depth were caught by the water current and carried into the equalizing reservoir. A paper dealing with this theme was published in German in the *Sci. Pap. Inst. Chem. Technol., Prague, Fac. Technol. Fuel and Water* 3 (2): *431—595*, 1959.

15. Prom. biol. J. Komárek, C.Sc. and doc. RNDr. J. Hrbáček, C.Sc.: "The productivity of the reservoir Slapy: 1. phytoplankton, 2. zooplankton." The phytoplankton was studied since 1957, the maximum concentration estimated near Županovice was 20.000 cells/ml. In the bays (being mouths of the tributaries) more phytoplankton was present than in the open water masses where it occurred in the upper part in higher numbers than in the lower one. The composition of the phytoplankton corresponds with the same of the main river. The water-blooms appear in the upper part of the reservoir and move gradually to the dam. — In the zooplankton samples gained through houls using three different Apstein's plankton nets the forms of nitrogen were determined. In the course of the summer 1957 six series of samples were collected and analysed. They originated from different localities lying in the longitudinal axis of the reservoir. The yield of fish in 1958 was 130 q from the entire reservoir having an area of 1392 ha. A higher yield is expected in future. A brief report was published in *Československé rybářství* 14(6): 83, 1959.

16. Ing. B. Václavík: "The present state of fish management of the reservoirs and the output of fish in future." The fish management in the reservoirs is only secondary business being unfavourably affected by the chief purpose of reservoirs. The choice of the fry must be improvised. In some reservoirs the unwelcome coarse fish increased in numbers to a great extent. An example is given on the perch which grazed all the spawn of the bream. The utilization of the coarse fish as food for the predatory one is recommended.

17. RNDr. O. Oliva, C.Sc. and prom. biol. S. Frank: "A contribution to the knowledge of the fish growth in the reservoir Slapy." 650 specimens belonging to 14 species were examined and the growth in the conditions of the reservoir Slapy was determined. The

results were compared with those gained in other localities or found in the literature. The *Cyprinidae* grew on an average or less than on an average, but the coarse fish and predators grew very quickly. The authors are of the opinion that the number of pike is to be increased.

18. Prom. biol. J. ČIHAŘ and RNDr. O. OLIVA, C.Sc.: "The growth of the bream in the reservoir Slapy". The main fish of this reservoir is the bream (*Abramis brama* L.). 95 per cent of fish gained by a trailing net consists of *Abramis brama*, *Rutilus rutilus* and *Perca fluviatilis*. The age and growth of 463 specimens was determined. In the reservoir some more populations of the bream are present growing in a different way, the growth in the upper part of the reservoir being slower that the same in the lower part. Generally spoken, the growth of the bream in the reservoir studied can be characterized as satisfactory.

19. RNDr. J. LELLÁK, C.Sc. and prom. biol. V. HRUŠKA: "A new method for determining of the influence of the fish stock on the bottom fauna and our experiences in applying it." Some perfectly enclosed spaces on the bottom of fishponds near Blatná were protected with the wire network against the fish and its predatory action. In this way an undisturbed development of the bottom fauna was made possible. On these spaces twice more benthic organisms were determined quantitatively than on the bottom area which was not sheltered. The findings enabled Dr. LELLÁK to state that about one half of the total increase of the fish meat was derived from the bottom fauna. On the other hand, prom. biol. HRUŠKA applied this method in some fishponds near Třeboň but his results were very heterogenous. A bare bottom was more utilized for the looking up of the food than the growths of makrophytes in the littoral zone. The new method of Dr. LELLÁK was described in a paper published in the German journal *Zeitschrift für Fischerei, N.F.* 6: *621—633*, 1957.

20. Prom. biol. M. STRAŠKRABA: "The role of the littoral zone in the productivity of fishponds." The author studied by means of quantitative methods the production of the littoral makrophytes, the periphyton, the littoral phytoplankton and zooplankton in two fishponds and compared the results with those dealing with the true plankton and benthos. He states that the primary production of the littoral is not sufficient enough for the food of the littoral zooplankton which has to feed in the pelagic zone consequently. The littoral zone is, therefore, the loss zone of the fishpond and diminishes its total production. The littoral makrophytes protect the littoral fauna against the voracity of the fish.

21. Prom. biol. K. LOHNISKÝ: "A comparative study on the food and growth of the perch." Many specimens of perch (*Perca fluviatilis* L.) originating from the reservoirs Slapy, Pastviny and Klíčava were

analysed. The best growth of this species occurred in the reservoir Klíčava, the worst in the reservoir Pastviny. The canibalism of the perch could be confirmed in a case found in the reservoir Slapy.

22. Ing. J. Libosvárský: "To the question of the present state of geographical distribution and the economical importance of crucian carps." In this country, the crucian carp (*Carassius carassius* L.) is considered as a noxious fish, growing very slowly, being competitor of the carp and interbreeding with the carp inconveniently. In the USSR, however, the crucian carp is an object of the pond management. The author believes that an introduction of the species *Carassius auratus gibelio* (Bloch,) into Czechoslovakian fishponds could be useful. It is not a competitor to the carp and it is resistant to the infectious dropsy. In the USSR the production of fishponds increased in many cases twice, when this species was added to the fish stock.

23. Ing. A. Lelek: "Some results of the ichthyological investigation of the rivulet Rokytná (Moravia)." In this rivulet 80 km of length live in the upper streamlet 8 kg of fish per 1 km, in the middle one 6,5 and in the lower one 4,5. Using an electrical aggregate 67% fish were gained at the first fishing on a definite locality, 26% at the second and 7% at the third one. *Chondrostoma nasus* L. and *Leuciscus cephalus* L. are the common fish caught in the water flow.

24. RNDr. E. Balon: "The development of fish in the infavourable food conditions". An experiment was made for demonstrating the influence of a shortage of food to the development of the wild Danubian carp and some other fish species. The starving larva of the Danubian carp reacted very sensitively to all motions in the water. In the time of the change of the endogenous for exogenous food the starving larvae did not survive for a longer time.

25. V. Mišík: "Fish of the drainages of the "Great Rye Island" with respect to the melioration works". In the newly built drainages a rich fish population was found. Closed areas of 25 cu.m. were fished by means of an electrical aggregate and 18 species of fish were determined. The standing crop of 10.000 up to 67.000 fish weighing 107 up to 631 kg per hectare was computed. This value can be compared with the same of the best Slovakian fishponds.

26. Doc. RNDr. I. Zmoray: "Some of the problems concerning the bioassays". Large series of bioassays directed to the determining of the toxicity of waste waters containing the remains of aniline dyes were realized by the author. As testing organisms the cultures of *Euglena* and the mustard seed (*Sinapis alba*) were applied with success. Comparing the results obtained by both methods the author recommends the cultures of *Euglena* as very suitable for everyday control analyses of the laboratories KHES (= Country hygienic and

epidemiological stations belonging to the Ministry of Public Health). The minute concentrations of the aniline dyes acted as stimulants to the germination of the mustard seed.

27. Mrs. prom. biol. V. Ottová: "The importance of fungi in the technical hydrobiology". There are very few species of fungi living naturally in freshwater, the most frequent one from these being *Leptomitus lacteus*. It is possible to detect that certain species of soil fungi can adapt for the life in water environment. The pathogenic fungi originating from sewage and industrial wastes can appear and do harm on irrigation fields.

28. Mrs. prom. biol. A. Sládečková: "The freshwater fouling and biological corrossion of submerged materials". These topics are little known in freshwater environments, for the time being. The author carried out a yearlong experiment in the reservoir Sedlice, where test panels of 16 sorts of materials were submerged in various dephts. Among the most fouled materials were wood, concrete, plexi-glass, and among the least fouled ones were copper, brass and zinc sheets. The results will be published in detail in the *Sci. Pap. Inst. Chem. Technol., Prague, Fac. Technol. Fuel and Water*.

29. Doc. RNDr. V. Sládeček, C.Sc.: "Biological classification of higher degrees of saprobity". A proposal of the unification, revaluation and a new biological classification was made. As a new collective designation for all kinds of sewage and industrial wastes may be used the term "eusaprobity" being in contradiction to the polluted surface and ground waters for which the term "limnosaprobity" is proposed and for which the scheme of Kolkwitz and Marsson comprising 5 degrees may be used continually. The new scheme for the "eusaprobity" includes 5 further degrees: 6, "persaprobity", 7, "metasaprobity", 8. hypersaprobity (Šrámek-Hušek, 1956), 9. "ultrasaprobity", 10, antisaprobity (B. and Z. Cyrus, 1947). For special cases, e.g. for the radio-active wastes, the term "transsaprobity" is to be applied. All the new terms are defined on the basis of qualitative as well as quantitative biological conditions and they are supported by fundamental chemical characteristics. The new classification was used by the author firstly in a paper published in the journal *Přírodovědný časopis slezský* 20 (3): *288—300*, 1959 and it will be discussed more in detail in a paper destined for *Archiv für Hydrobiologie* being under preparation.

30. RNDr. M. Zelinka: "To the precision of the biological classification of clean waters". On the basis of ten years investigation of the biology of practically all moravian streams the author proposes that the oligosaprobic degree in the systeme of saprobity by Kolkwitz and Marsson should be divided into two degrees, the beta-oligosaprobity designating the cleaner streams or streamlets and the

alpha-oligosaprobity designating the less clean streams. The term katharobity is not applicable for the surface waters at all and it should be reserved only for ground water and springs. The difference between the both degrees of oligosaprobity has been proved also by chemical analyses. A detailed list of biological indicators of both degrees of oligosaprobity is appended to a paper appearing in the *Sci. Pap. Inst. Chem. Technol., Prague, Fac. Technol. Fuel and Water* 4 (1), 1960.

31. Prom. biol. J. Švec: "The effects of tannery wastes and their components on the water organisms." Bioassays were applied for the study of wastes from different technological procedures as well as the final industrial waste led into the treatment unit. *Tubifex*, cladocerans and small aquarian fishes were used as testing organisms. Some of the single wastes have to be treated separately because of their high toxicity. The lecture was published in the Czech journal *Vodní hospodářství* 9 (11): *494—497*, 1959.

32. RNDr. Ladislav Hanuška: "Saprobiology of the Danube and a forecast for the planned reservoir". The Danube comes to the territory of Slovakia in oligosaprobic state of purity, becomes worse under the city of Bratislava, but the biological selfpurification proceeds very quickly so that the final degree of pollution at the end of the course of Danube in Slovakia corresponds to the better beta-mesosaprobity. The planned reservoir will be a suitable place for the accumulation of organic matter involving the development of water-blooms during summer months. An inconvenient influence is to be expected concerning a thin oil film present on the water surface.

33. Prof. RNDr. V. Teyrovský: "A contribution to the ecology of *Corixidae* in running waters". In the vicinity of the town Olomouc the author collected and statistically treated the corixids living in the river Morava. At the beginning of the mass development of *Sphaerotilus natans* in autumn, the numbers of corixids decreased. They are generally not approved as indicators of the water quality, because they can fly and they respirate the atmospheric oxygen. But some species, e.g. *Sigara praeusta*, show a distinct relation to polluted waters.

34. RNDr. F. Kubíček: "To the knowledge of the zooplankton of the reservoir Vranov". Since the time of Haempel and Stundl (1943) no principally changes in the zooplankton composition could be recorded. Only the ratio between the main components of the zooplankton changed. In the time present the crustaceans predominate and the rotifers occur in less numbers. The vertical distribution of the zooplankton was found as unequal with a maximum in the epilimnion and another smaller one at the bottom (consisting of *Bosmina longirostris* and cyclopids). In the horizontal sense a higher

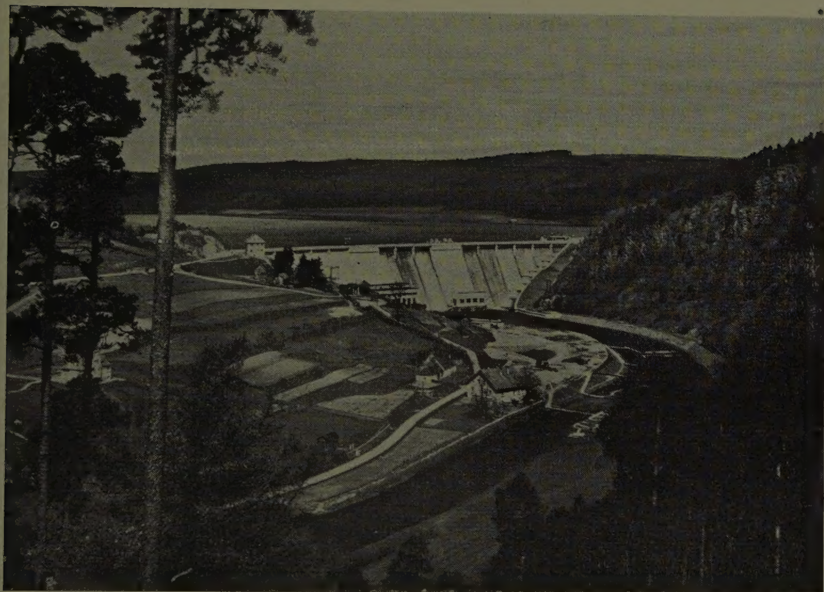

Fig. 1. The reservoir Vranov situated on the river Dyje in South Moravia (A card.)

Fig. 2. The dam of the reservoir Vranov with a power plant. The reservoir is full and the water is flowing over the dam (A card).

concentration of the zooplankton is detectable more in the upper part than in the lower part of the reservoir. The two inflow branches have different plankton community. On the other hand, the bays of the reservoir show the same zooplankton composition as the proper reservoir. The numbers of coliform bacteria decrease in the stagnant water of the reservoir when compared with those in the inflow branches.

35. Prof. RNDr. S. HRABĚ, D.Sc.: "Notes on the excursion across the reservoir Vranov". The dam has a length 290 m, is 47 m high and in the base 40 m wide. The reservoir has an area of 763 ha and a volume of 122 million cu.m. This reservoir was studied biologically by HAEMPEL and STUNDL (1943), the thermal stratification was described by KRATOCHVÍL in three papers and some of the pelagic crustaceans by ŠRÁMEK-HUŠEK (1957). A large series of unpublished data is available in the library of the Zoological Department of the University of Brno (HUDEC, VLČKOVÁ) and in Hydraulic Research Institute in Brno (Zelinka). In the time present the zooplankton is studied by F. KUBÍČEK. The facilities for the research work are available here since 1950 when a small hydrobiological station was established in the castle Bítov. But this station has no permanent staff and it serves mainly for the educational purposes of the University of Brno.

The conference was terminated by doc. RNDr. R. ŠRÁMEK-HUŠEK, D.Sc., who valuated the program and the arrangement. The lectures dealt in the majority of cases with original research activity of individual workers or teams and their quality has to be indicated as good. The discussions were objective, lively and in some cases critical. The personal contact of the participants among themselves and with the foreign guests was very useful. A resolution was then accepted in which the main programmatic lines of the further hydrobiological work in Czechoslovakia were given. It was decided, that the next sixth national conference should be held in autumn 1961 in Slovakia.

The last day of the conference, September 13th, 1959 was spent on a nice excursion to the dam and the reservoir Vranov nad Dyjí (see figs. 1 and 2). The majority of the participants sailed in a motor vessel lengthwise the reservoir and visited the small hydrobiological station situated in the castle Bítov near the upper part of the reservoir Vranov.

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